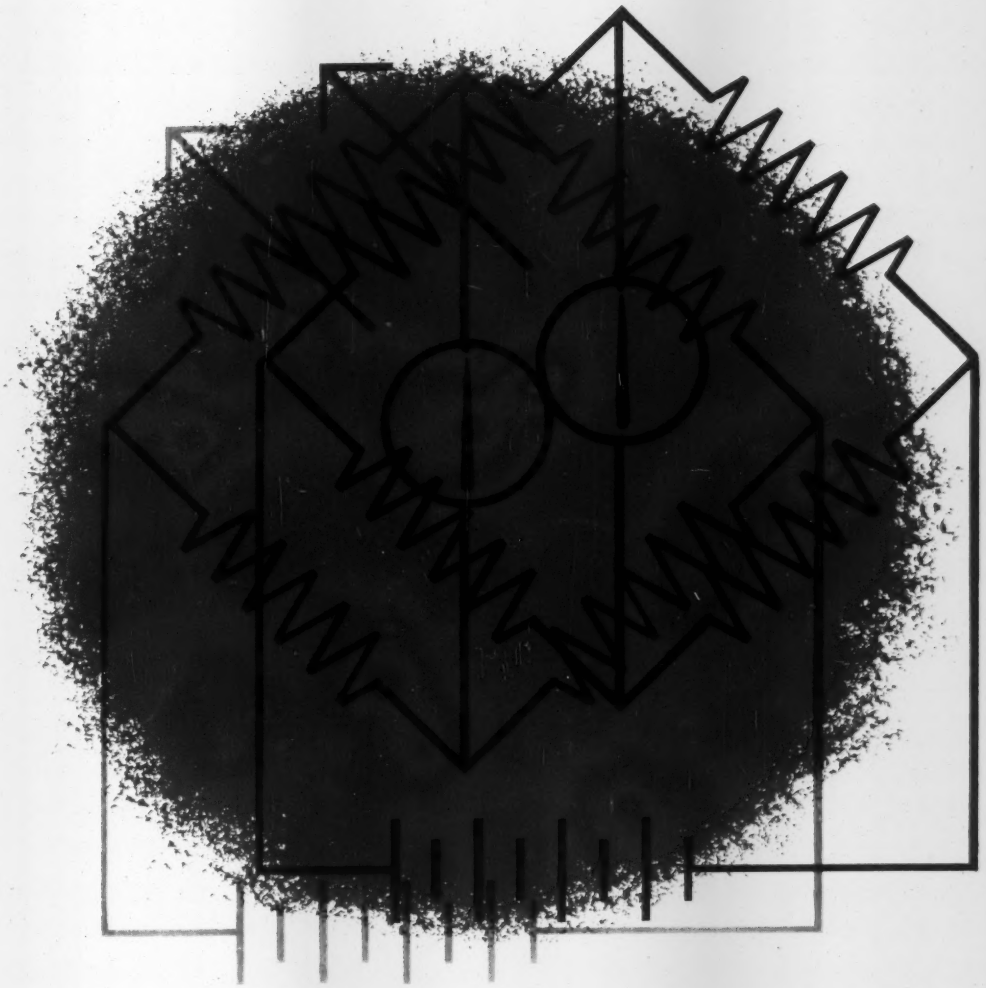
INSTRUMENTS AND CONTROL SYSTEMS

INCLUDING: INSTRUMENT MANUFACTURING • JOURNAL OF THE SOMA • SIMULATION COUNCIL NEWSLETTER



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SEPTEMBER 1959

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LIBRASCOPE SHAFT-TO-DIGITAL ENCODERS *adapt to a variety of applications, providing the direct means for presenting analog to digital data conversion with verbatim accuracy.*

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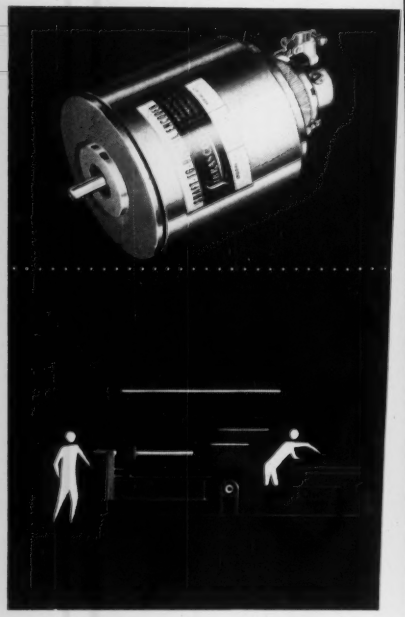

CODE OUTPUT	MODEL NO.	TOTAL CAPACITY	RESOLUTION PER TURN
SERIAL BINARY (LINEAR)	707	7 bits (128)	128
	713	13 bits (8192)	128
	717	17 bits (131,072)	128
	719	19 bits (524,288)	128
BINARY (SIN-COS)	757*	7 bits per quadrant	512
	758*	8 bits per quadrant	1024
BINARY CODED DECIMAL	723 through 735	2,000 through 360,000	200
GRAY	708	8 bits (256)	256
BINARY	740	10 bits (1024)	1024

*Available in hermetically sealed servo-driven package as Models 757-S and 758-S.

For information on career opportunities at Librascope, write Glen Seltzer, Employment Manager.

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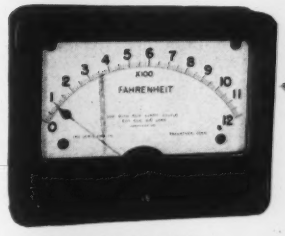
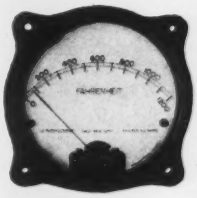
This instrument has been used extensively by the leading motor-car manufacturers for road testing on the "Proving Grounds" — where performance counts. Housed in a rectangular bakelite case, this reliable, fully compensated pyrometer is furnished with 6 in. hand drawn scales for greater accuracy. The Model 58PY is available for use with all standard thermocouple materials, in many ranges to suit the most exacting application.



MODEL 58PY

Manufactured with the same type of movement as our aircraft pyrometers, the Model 23B pyrometer is well suited for use in moving vehicles and has been successfully used in many marine diesel installations for measuring exhaust temperatures. It is housed in a 4 in. round bakelite case that is flanged for panel mounting, and is available in several ranges for use with various thermocouple materials.



MODEL 23B

The Model 20B series of indicators are patterned after our standard aircraft instruments and are supplied with 3" round steel cases suitable for panel installation. These compact, sturdy indicators have 2⅛ in. scales, are fully cold-end compensated and are available in many ranges for use with various thermocouple materials.

MODEL 20B

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THERMOCOUPLES for use with the above indicators are available in many styles for special applications. We have developed a complete line of aircraft, industrial and automotive thermocouples and would be pleased to offer our recommendation for your application.

THERMOCOUPLE LEAD WIRE for connecting thermocouples to the indicators is manufactured in iron-constantan, copper-constantan or chromel-alumel material with standard and special insulation. Use Lewis lead-wire with Lewis instruments and thermocouples for best results.

RESISTANCE BULBS for use as sensing elements for the 62RT4 thermometers are available in several types for various applications, for measuring free air or liquid temperatures. We invite inquiries on your application.

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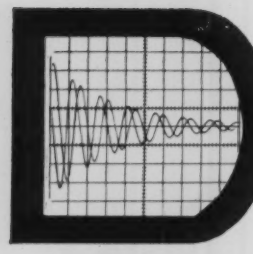
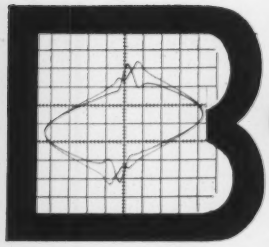
CIRCLE 2 ON READER-SERVICE CARD

Dual Beam

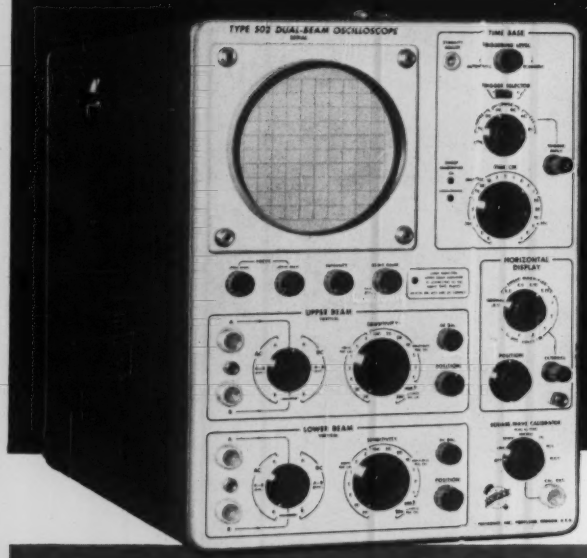


DUAL DISPLAY ON LINEAR TIME BASE—Comparison of waveforms at two points in a ringing circuit. This kind of display is useful in many types of investigation.



DUAL-BEAM X-Y CURVE TRACING—Typical production-test application: display of EI loops of two transformers manufactured under identical conditions.

Type 502 Tektronix Oscilloscope



TWO-GUN CATHODE-RAY TUBE.

200 μv/cm SENSITIVITY, BOTH BEAMS.

DIFFERENTIAL INPUT, ALL SENSITIVITIES.

2, 5, 10, and 20 TIMES SWEEP MAGNIFICATION.

X-Y CURVE TRACING with TWO BEAMS—(horizontal input sensitivity to 0.1 v/cm).

SINGLE-BEAM X-Y CURVE TRACING at 200 μv/cm, BOTH AXES.

EXTRA FEATURE—Both amplifiers have transistor-regulated parallel heater supply.

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200-microvolts/cm deflection factors, both dc-coupled and ac-coupled. 16 calibrated steps from 200 μv/cm to 20 v/cm.

Passbands—dc-to-100 kc at 200 μv/cm, increasing to dc-to-200 kc at 1 mv/cm, dc-to-400 kc at 50 mv/cm, and to dc-to-1 mc at 0.2 v/cm. Vertical response at the lower sensitivities varies according to switch position as follows: 0.5 v/cm—dc-to-300 kc, 1 v/cm—dc-to-500 kc, 2 v/cm—dc-to-1 mc, 5 v/cm—dc-to-300 kc, 10 v/cm—dc-to-500 kc, 20 v/cm—dc-to-1 mc.

Differential Input, Both Channels—Rejection ratios: 1000-to-1 at 1 mv/cm or less, 100-to-1 at 0.2 v/cm, 50-to-1 at 5 to 20 v/cm.

Constant Input Impedance, 1 megohm, 47 μμf, both channels.

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OTHER FEATURES

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Electronically-regulated power supplies.

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IN MECHANICS—Display, compare, and measure outputs of two transducers on the same time base; plot one transducer output against another—pressure against volume or temperature for instance; measure phase angles, frequency differences, etc.

IN MEDICINE—Display, compare, and measure stimulus and reaction, or the outputs of two probes, on the same time base; use differential input to cancel out common-mode signals, or to eliminate the need for a common terminal; use in routine investigations, etc.

IN ALL FIELDS—The Type 502 can save you more than its cost in time—in as little as one application!

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Formerly INSTRUMENTS and AUTOMATION

SEPTEMBER 1959

VOLUME 32 NUMBER 9

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Creative Thinking, 1349

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G. J. FLEMING—resistivity of stainless-steel arc-welding rods and coated electrodes can be used for accurate identification of wires

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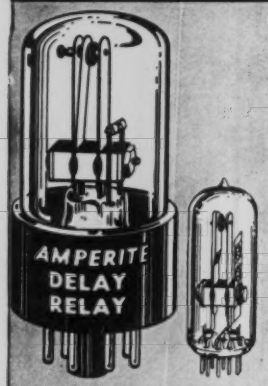
AMPERITE

THERMOSTATIC
DELAY RELAYS



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Compensated for ambient temperature changes from —55° to +70° C. Heaters consume approximately 2 W. and may be operated continuously. The units are rugged, explosion-proof, long-lived, and—inexpensive!

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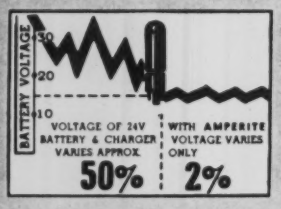

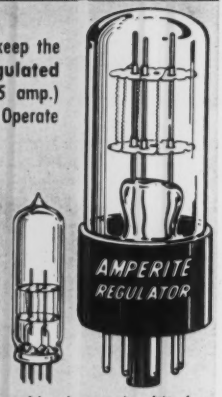

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REGULATORS—CIRCLE 5 ON READER-SERVICE CARD

INSTRUMENTS AND CONTROL SYSTEMS

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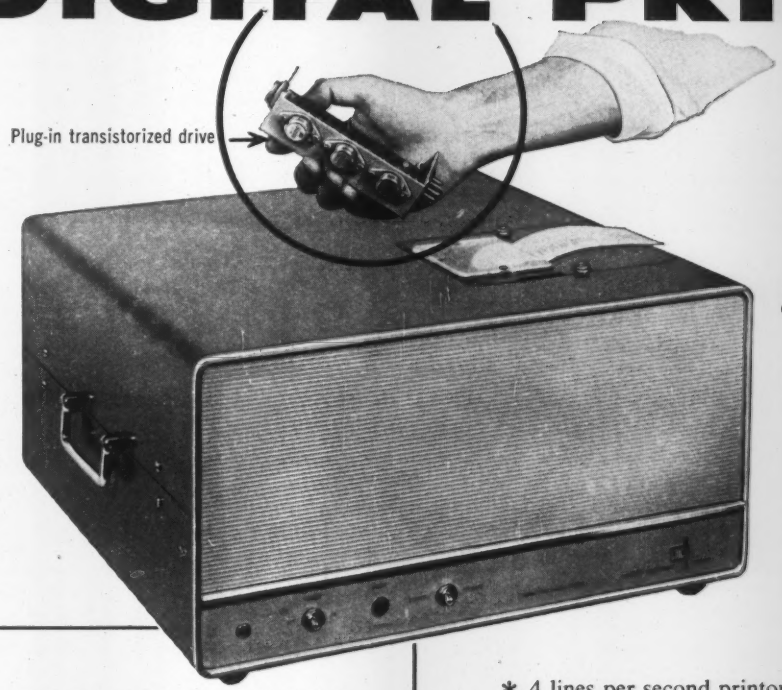

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The most versatile digital printer ever made

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Weight	60 lbs.
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Price	$1350.00. Add $10.00 for rack mount.

* 4 lines per second printout * Takes 1-2-2-4 or 1-2-4-8 four line code * No stepping switches * Operates from only 6 volt input * Parallel entry * Special options available including 10 line and analog output * 6 digit printout, up to 12 digits on special order * Rugged unitized construction * Completely compatible with CMC's new solid state frequency-period counters, and other types of transistorized counting equipment.

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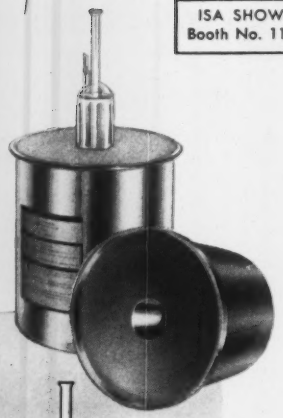
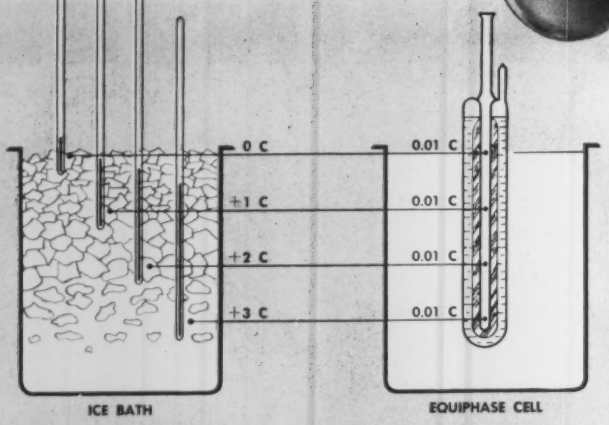
There does not appear to be any better way to establish a standard for temperature.

ISA SHOW
Booth No. 117

EQUIPHASE*

Triple-point-of-water CELL





The triple-point-of-water is a physical constant which defines the Thermodynamic Temperature at 0.0100 C when water exists in equilibrium with its ice and vapor at a pressure of 4.58 mm Hg. "By taking a physical constant to define our temperature scale, we have gained a great deal and lost nothing in precision of temperature measurement. There does not appear to be any better way to establish a standard for temperature."†

The Equiphase Cell is an instrument for realizing the stable temperature established by the triple-point-of-water, with a guaranteed accuracy of better than 5×10^{-4}C.

The conventional ice bath is impractical for use as a true temperature reference because it is liable to errors of varying magnitudes including: failure to achieve equilibrium between ice and water (error to 3.98 C); dissolved impurities, salt (error to 2 C) failure to air-saturate the water (error to 0.0024 C); atmospheric pressure (error to 0.0017 C).

With the Equiphase Cell, on the other hand, the triple-point-of-water is established, which is by definition a fundamental fixed point at exactly 0.0100 C on the Thermodynamic Temperature Scale.

Equiphase Cells are now available in a convenient, easy-to-use package, complete with instruction booklet. These instruments are 17″ high and 8″ in diameter. Write for Equiphase Cell Technical Bulletin to Trans-Sonics, Inc., Dept. 19, Burlington, Mass.

†A. G. McNish: "The Basis of our Measuring System", Proceedings of the I.R.E., May, 1959
*Trademark

TRANS-SONICS T.M.
Precision Transducers

CIRCLE 7 ON READER-SERVICE CARD

to the editor

Editor, I&CS:

Please let me express my appreciation for the (inquiry) item which you ran in your magazine when we were attempting to locate a source of small diameter Teflon tubing. We were agreeably surprised at the number of helpful replies.

An order has already been placed with one of the companies that replied. The tubing has been received and found to be completely satisfactory. What at first appeared to us to be a difficult problem has been simply solved with your assistance.

J. M. Brian
General Manager
Brian Engineering, Ltd.
Montreal, P. Q.

Editor, I&CS:

I wish to extend my sincere appreciation for the (reader inquiry) services rendered in the past issue of *Instrument and Control Systems.*

Since this department is continually searching new areas of interest, it is a pleasure to know of your service, especially when rendered with such promptness and courtesy. The letters forwarded in response to our request for moisture and efficiency meters were most helpful in arriving at our present decision.

Richard Dineen
American Machine & Foundry Co.
Stamford, Conn.

Editor, I&CS:

As you have noted [in your editorials] the National Science Foundation follows a practice of making grants to colleges, universities, research laboratories and professional and scientific societies in conducting its programs in the field of science education. We do not make grants directly to secondary schools or to state or local secondary school systems. This does not imply that the Foundation does not recognize the important part which public school officials play in secondary education. Neither does it mean that the Foundation lacks confidence in the officials administering the public schools.

The National Science Foundation,

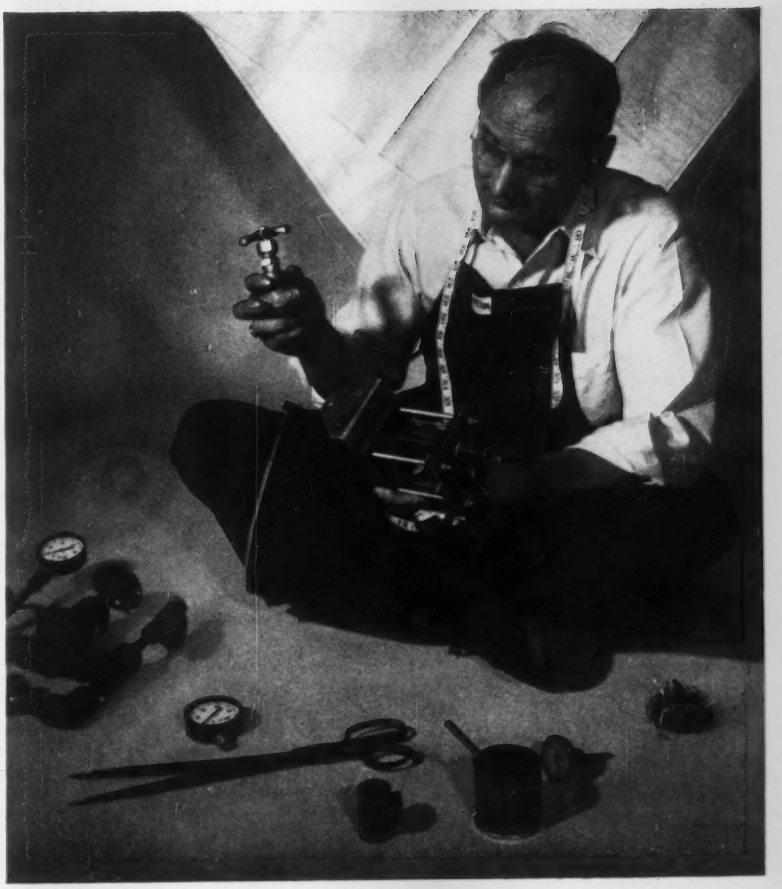
as you know, is not the only agency of the Federal Government that is concerned with public education. The Office of Education of the Department of Health, Education and Welfare, has the specific responsibility of dealing with state and local school systems in behalf of the Federal Government. Where Federal funds are allocated for the direct support of educational activities of state and local agencies, these are usually administered by the Office of Education.

The National Science Foundation in carrying out its legislative directive "to develop and encourage the pursuit of a national policy for the promotion of . . . education in the sciences" has provided a focal point for Federal Government concern in science education. It has made funds available to the scientific community through professional scientific societies, institutions of higher education and research agencies that permit scientists to direct some of their creative talent and energy to the improvement of secondary school science education.

As you have pointed out in your editorial, the Pittsburgh program has been conducted effectively with local industrial support. Such local support of science education is essential if the necessary advances are to be made. The National Science Foundation does not undertake to replace effective local activity. Its programs in support of science education are of necessity national in scope and designed to be as applicable to rural areas as to metropolitan industrial areas.

I should point out that you have apparently been misinformed with regard to the Foundation's Visiting Scientists Program in physics. This program has been devoted primarily to improvement of college teaching of physics, not high school teaching, and total grants to date for this purpose have been $68,400. During 1958-59 an experimental program of visiting scientists in physics was conducted at the high school level on the basis of a grant of $24,265, made to the American Institute of Physics, a national scientific society. The reaction of the secondary school science teachers concerned in this program has been extremely favorable and we have reason to believe that it has been very effective in bringing about an improvement in the understanding of modern physics by high school teachers and students where it has been undertaken.

There is, of course, no single solution to the problem of presenting high school physics properly. Pro-



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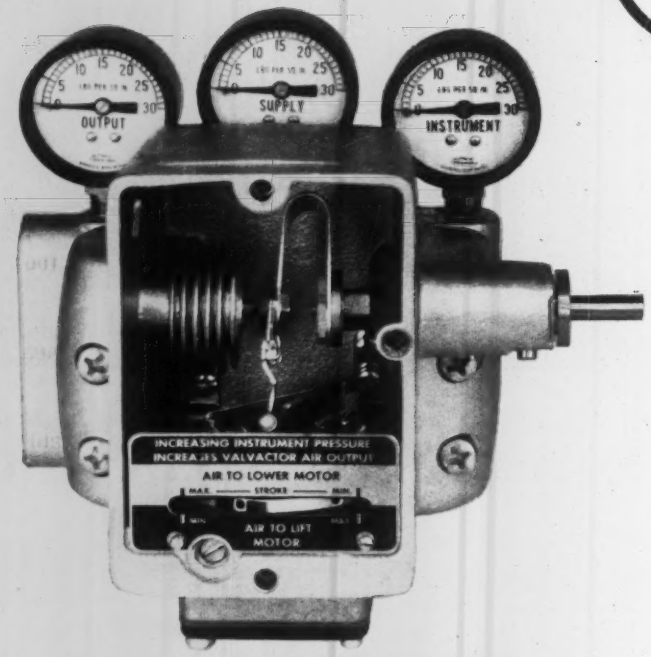
VERNIER VALVACTOR*

MOST UNIVERSALLY ADAPTABLE VALVE POSITIONER ON THE MARKET!



The Type C Valvactor's distinctive motion-balance principle of stem positioning eliminates loading effects of heavy fixed-stroke actuating springs. Note compactness — the simplest mechanical design of any valve positioner.

**Trademark of a precision valve positioner made by The Foxboro Co.*

Unique Flexibility Easily reversible in seconds. Sequencing by two simple adjustments.

Super Response Full air-pressure output to diaphragm motor on signal air-pressure change as small as ½ of 1% of signal span.

Extra Speed New, high capacity relay provides high speed positioning action.

Positive Positioning Direct, motion-balance feed-back assures instantaneous, pin-point positioning.

Now there's a positive-action, super-precision valve positioner that you can easily adapt to *any* diaphragm motor application — without exchange of parts! It's the Foxboro Type C Vernier Valvactor with unique motion-feedback.

The Type C Valvactor has a master setting disc which provides easy change of action as required by the control system, as well as easy reversal of Valvactor action for air-to-open or air-to-close control valves. Adjusting for limited stem travel is equally simple ... sequencing of several valves is a cinch!

The Valvactor is the ideal solution to such problems as stem friction, plug friction, valve motor and transmission line lag, and extreme process line pressure changes. And it requires practically no maintenance! Available with 3-gauge and by-pass manifold, or plain manifold. Write for full details.

The Foxboro Company, 469 Norfolk St. Foxboro, Mass., U.S.A.

FOXBORO
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CONTROL VALVES AND POSITIONERS

CIRCLE 9 ON READER-SERVICE CARD

grams such as the one that you are associated with, supported locally by industry, are very worthwhile. I wish you every success in continuing it.

Harry C. Kelly
Assistant Director for
Scientific Personnel
and Education
National Science Foundation
Washington 25, D. C.

Although problems in technical education exist at all levels, the core of the problem is at the secondary school level where the student must first be attracted into science and prepared to assimilate college-level curricula. The NSF directive includes "promotion of education in the sciences." Very little is being done, by anybody, at the critical high school level.

Editor, I&CS:

I have read with a great deal of interest, the article in March *INSTRUMENTS AND CONTROL SYSTEMS* entitled "A Threat to American Education and the Instrument Industry."

While I agree that a good theoretical background is necessary part of any engineering course, I believe that it is wrong to turn out an Engineer without any conception of the mechanics of modern instrumentation.

This was the case when I graduated and I know it is still the case.

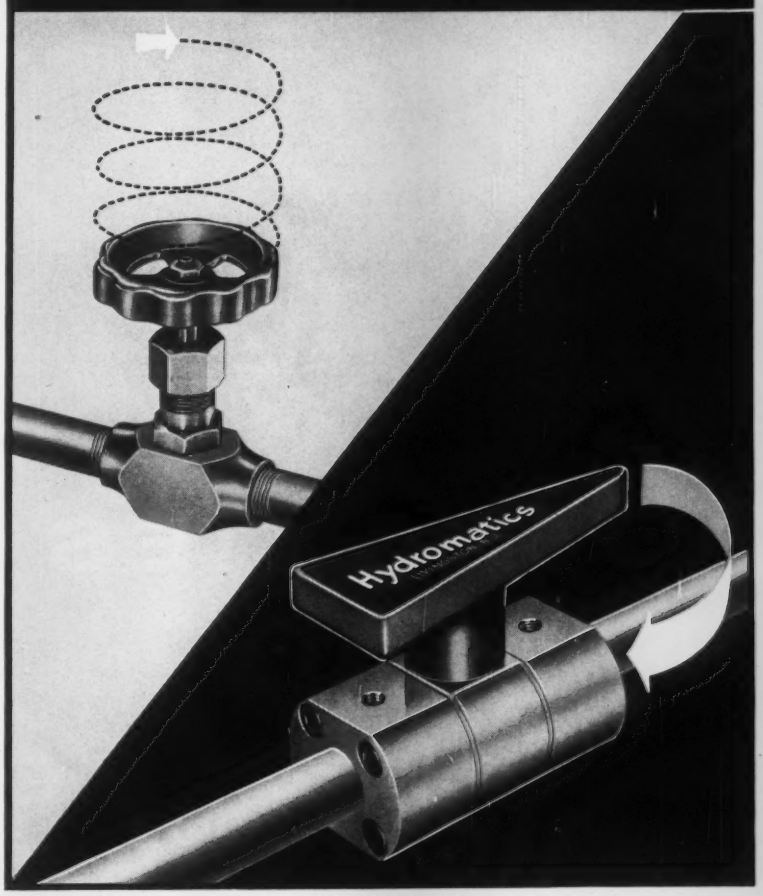
While our leading industries can afford to take a man in and educate him about the hardware, there is certainly a crying need for men with a good theoretical background who do understand how an instrument functions. All industries and plants cannot afford the luxury of a two or three year educational program to give them a practical instrument working knowledge.

The "Pittsburgh High School Program" did not spoil any of the students and, from my own observation, only whetted the appetite of the students to learn more and gave them a background of knowledge that will help them absorb the theory which they will obtain in college. Pure theory without the opportunity of knowing the equipment to which the theory applies results in extremely dull study.

I personnally tried to interest both FIER and the ISA Executive Committee in this Pittsburgh Program, but had no support.

Let us, either thru FIER or our own Educational Committee, make an effort to see that Instrument Engineers come out of Technical Schools with a real appreciation not only of the theory but also of the hardware

FLO-BALL 715
makes needle valves obsolete



WHICH VALVE CLOSES FASTER?

Unlike the many turns required to operate a needle valve, the Hydromatics ***FLO•BALL 715***, shown on the bottom, closes instantly with a mere ¼ turn . . . **positive action** at flow pressures up to 3,000 psi with just a 4 inch-pound torque! And the arrow-shaped handle shows both open and closed positions at a glance. Exclusive ***FLO•BALL*** straight-thru design has 100% flow efficiency—more than double the flow of needle valves.

Ideal for leakproof control of air, vacuum, steam, water, fuels, oils, kerosene, alcohol, etc., the ***FLO•BALL*** features zero leakage, universal mounting, removable flanges, and all stainless steel construction.

Write today for a complete catalog describing this valve and others for corrosive and cryogenic media. Also special designs for throttling flow control.

The *FLO•BALL* costs no more than old fashioned screw-type valves!

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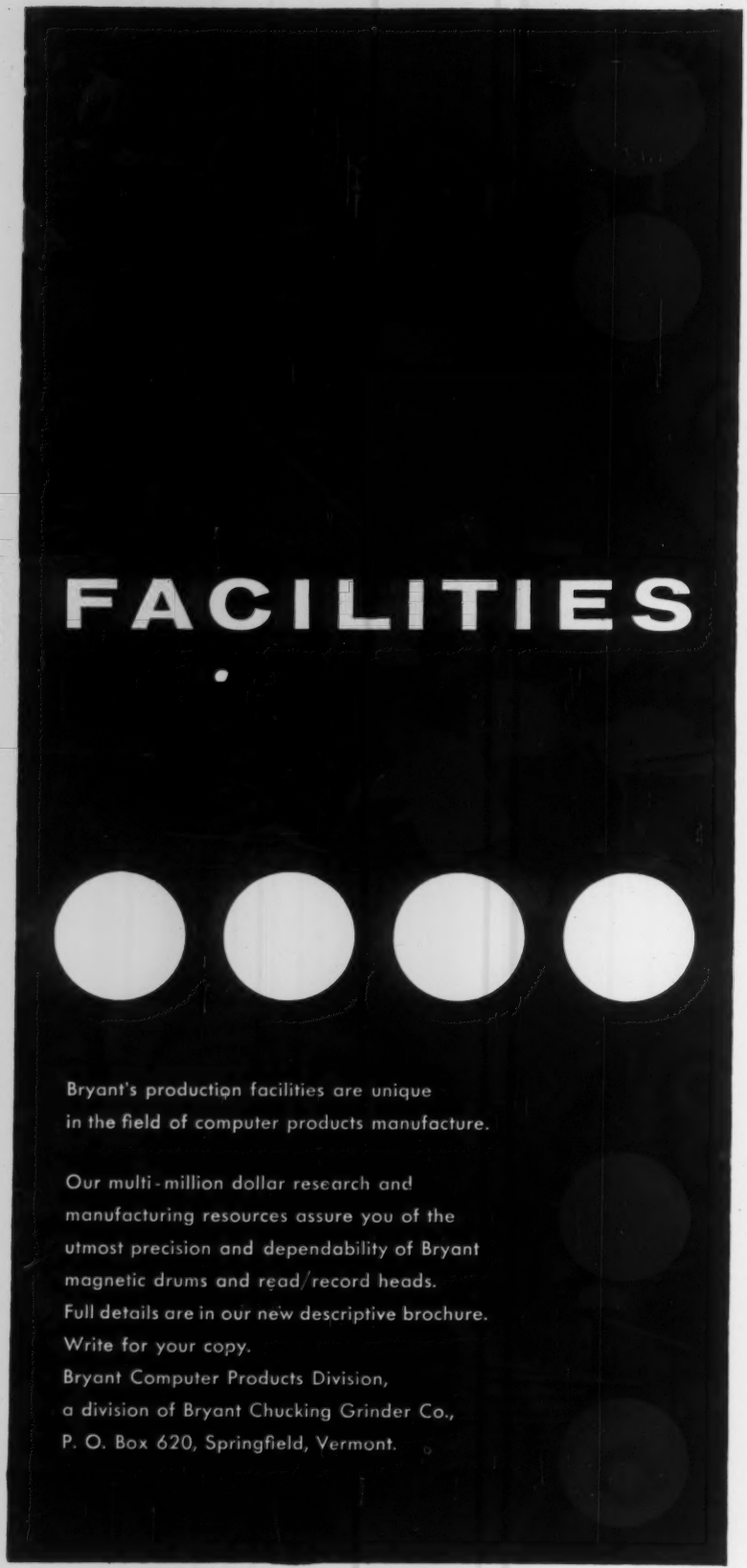
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CIRCLE 11 ON READER-SERVICE CARD

LETTERS—CONTINUED

of Instrumentation, and not have to spend half a lifetime at an educational institution to accomplish this. I believe that an introduction to the elementary hardware of Instrumentation is not out of place at the High School Level and should be a "must" in every Engineering School.

Mifflin S. Jacobs
Pittsburgh, Pa.

Editor, I&CS:

We are planning to establish an Instrumentation Education program in this city similar to the one which you sponsored in Pittsburgh. My advisory committees are meeting to plan our program of studies.

It would be most helpful if you would send to me for review two copies of your publication *Instruments and Control Systems*" and two copies of "*Electronic Circuitry for Instruments.*"

William E. Brunton
Director
School District of Philadelphia
The Board of Public Education
Philadelphia, Pa.

Editor, I&CS:

Please send me a re-print of your article "Report on Public High School Course in Modern Engineering Physics" which appeared in the February 1959 issue of "*Instruments and Control Systems.*"

J. L. Hayes
Leeds & Northrup Co.
Phila., Pa.

Editor, I&CS:

The Letter to the Editor of Professor John Henry in the July issue of *Instruments and Control Systems* has aroused my interest. Instrument evaluation is a subject which is of extreme importance and is a function of the section which I administer here at AVCO R.A.D.

Our operation is not very old—we reestablished ourselves in our new quarters in Wilmington in August 1958, after a stay of eighteen months in temporary quarters in Lawrence, Mass. Fortunately, however, the youth of the organization permitted us to establish controls which permit extensive analysis of a number of operations.

First—one function of this Section is the incoming inspection, repair, maintenance, and calibration of all test instrumentation employed

within the Division. Through tight control of data and incorporation into IBM listings we have been able to control a program involving over 11,000 instruments. Presently, we are engaged in the tedious task of extracting data from our Case History Files which will enable us to evaluate the performance of instruments alike in function but supplied by differing and competitive manufacturers. This last function of ours is not officially recognized by management as yet, consequently it must be performed by a working force carrying on a normal day's activity and finding time for this auxiliary work. However, unofficially, the work is recognized since it is required that this Section review and pass on the instrumentation requirements of the Sections.

Another function of this Section was to establish and maintain "a capability in the field of Standards suitable for the conduct of the Company's business of research and development." I presented a paper last year at the National Conference on Standards outlining the establishment of our Laboratories. Also, I have developed a statement of capabilities in the measurement field.

I hope Professor Henry will continue his investigations in this field.

Charles E. White, Chief
Laboratory Measurements Section
Research and Advanced
Development Div.
AVCO Corporation

Editor, I&CS:

We have to thank you very much of your spirit of cooperation and courtesy in sending us the useful information about the flight recorder for civil airlines.

Ing. E. Bortignoni
Aeroporto Caselle Torinese
Italy

Editor, I&CS:

In your May, 1959 issue, Vol. 32, page 773 and in your July, 1959 issue page 1078, you have described a digital linear positioner wherein a number of cylinder units are operated to produce a binary progression. It would be appreciated if you would send me additional information.

Baylor G. Riddell
Santa Clara, Calif.

These and other digital positioners and actuators are made by Ferguson-Hille and Associates, Inc., 542 S. Dearborn St., Chicago 5, Ill.

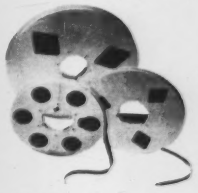
5-702 MOBILE RECORDER IN CAST-MAGNESIUM CASE
MINIATURIZED AMPLIFIERS STACKED ON POWER SUPPLY
CEC TYPE 1-151 FM RECORD AMPLIFIER

QUITE A HANDFUL OF PERFORMANCE is packed into CEC DataTape's Mobile Recorder . . . a complete 14-channel system in less than 2 cubic feet. And compact size and precision operation do not mean delicate construction. You can fly this system up to 70,000 ft. with the assurance that rigid, featherweight cast-magnesium cases will hold all components in their original precise alignment, even during high-G pullouts. No false data from bending or twisting moments. If you want to use it in the desert the 5-702 comes with a dust cover which seals tape and drive components against contaminating environments. MIL-E-5400B, Class II Airborne Specifications are adhered to throughout.

Individual plug-in amplifiers weigh only 10 ounces each, are available for Analog, FM, and PDM recording modes, and are interchangeable, of course. The FM amplifier is a new design and handles frequencies from d-c to 20 kc with the most outstanding linearity and freedom from drift we have ever seen. You can obtain more information on this versatile mobile system from your nearest CEC sales and service office. Or simply write for Bulletin CEC 1578-X4 and 1592-X3.

DataTape Division CEC

CONSOLIDATED ELECTRODYNAMICS / 360 sierra madre villa, pasadena, california



INSTRUMENTATION TAPE, analog and digital, now available from CEC DataTape, is manufactured, tested and spooled to highest industry standards. Write for Bulletin CEC 1619-X1.

CIRCLE 12 ON READER-SERVICE CARD

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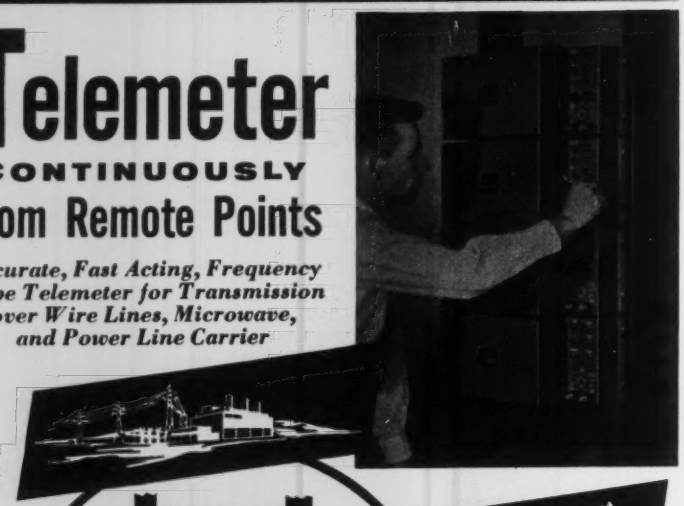
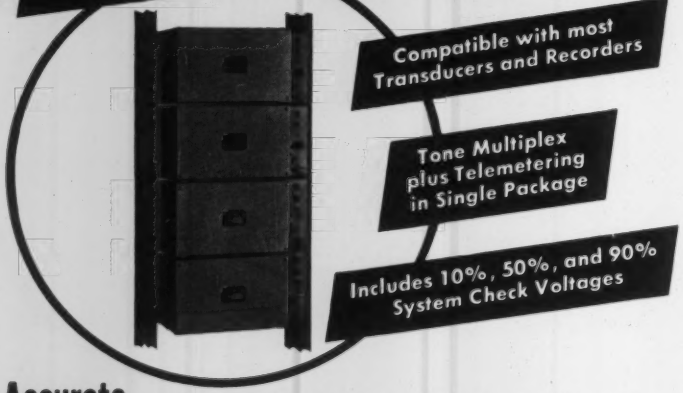
Telemeter
CONTINUOUSLY
from Remote Points

Accurate, Fast Acting, Frequency Type Telemeter for Transmission over Wire Lines, Microwave, and Power Line Carrier




Compatible with most Transducers and Recorders
Tone Multiplex plus Telemetering in Single Package
Includes 10%, 50%, and 90% System Check Voltages

Accurate HIGH-SPEED Analog Telemeter for VOLTS AMPS WATTS PRESSURE FLOW TEMPERATURE etc.

The Model 1025 Telemeter Transmitter converts DC mv from thermal converters, or other transducers with a DC mv output, to an output of 10 to 30 cps. If multi-channel operation over a single communication circuit is required, the 10 to 30 cps signal is used to modulate a built-in frequency shift tone channel. The Model 1090 Telemeter Receiver detects and demodulates the transmitted signal and generates a DC current or voltage which varies in exact accordance with the telemetered functions. The receiver output may be directly applied to either recorders, indicating instruments, or both.

The equipment is conservatively designed for continuous duty operation. The over-all accuracy of the Telemeter is 1% with a speed of response of one second.

SEND FOR TECH. DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

WE CAN HELP YOU — Our Applications Department is ready to assist you in your control, telemetering or communications problem.

Radio Frequency LABORATORIES, INC.
Boonton, New Jersey, U.S.A.

CIRCLE 13 ON READER-SERVICE CARD

LETTERS—CONTINUED

Editor, I&CS:

We are interested in purchasing copies of your magazine for January and February, 1958, on the subjects "Systems Engineering" and "Iron and Steel Automation." Also, any other publication on the subject of iron and steel plant instrumentation.

Norman D. Weiner
Dominion Steel and Coal Corporation
Canada

Every issue of *I&CS* has material pertinent to iron and steel instrumentation. For example, the series "Process Systems" has many boiler house and steel mill control systems.

Editor, I&CS:

We are happy to note that your columnist, Panhandle Pete, has received a compilation of Finagle's laws. In a private communication, Mr. B. T. Factor has warned us that these laws are of universal application, and further that no one has yet made a compilation without being affected by a corollary of Axiom #1: "In any communication of engineering data, egregious errors will be noted only after the postman leaves."

As usual, Mr. B. T. Factor, was right, but we are curious; how long after the issue went to press did you notice "susequent" in Axiom #7?

P. H. Gilson
Combustion Engineering, Inc.
Chattanooga 1, Tenn.

Several axioms were involved, as follows: The word was originally set properly but the word immediately after it was spelled wrong as follows: "subsequent prduction."

We asked the printer to correct the mistake and, logically (according to axioms 1 and 7), the result was "susequent production."

Editor, I&CS:

Congratulations on your compilation of the Universal Laws of our profession and on your courage in publishing this invaluable information. I very much fear that you will be subject to severe criticism. Manufacturers and customers alike will be outraged at your exposure of their secrets. The academician will be horrified at the connection, which you have clearly implied may exist, between theory and practice. When the storm bursts upon you, I hope you will take comfort from the posi-

tion of all good consulting systems engineers, who will exhibit their impartiality by standing by and not interfering.

I must express surprise at your omission of one of the Laws which surely comes first in the experience of many of us: "When a feedback loop is first closed, the sense of the connection will be wrong and the system will oscillate; and this will inevitably happen, quite independently of preliminary planning, no matter how thorough."

Samuel A. Scharff
Consulting Engineer
New York 17, N. Y.

Editor, I&CS:

I am scheduled to present a paper on "The Application of Research and Development Techniques to Engineering and Maintenance Problems" at the National Plant Maintenance and Engineering Conference to be held in January, 1960.

I plan to distribute information sheets to those attending the sessions at which this paper will be given, and I should like to include "Finagles Universal Laws" from your May issue.

I feel that these axioms are very pertinent to the subject of my paper.

J. H. Pfau
Philip Carey Manufacturing Co.
Plymouth Meeting, Pa.

Permission granted by Panhandle Pete

---

reader inquiries

Alarm

President of cleaning establishment seeks "apparatus that would automatically ring a bell for starting and stopping time in our plant, preferably to be attached to our time clock." A-427

Thermostat

Engineer is seeking bimetallic or mercury-type thermostat with an accuracy of about 0.5° F at a permanent setting near 100° F, with overrange protection to 212°F. A-428

Displacement Meter

Purchasing agent of large paper manufacturing concern seeks portable displacement meter of the contact type with direct recording feature. A-429

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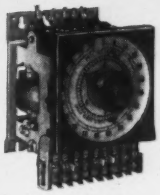
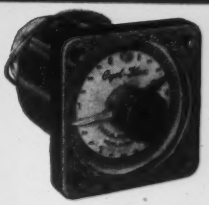
QUALITY BUILT • EASY TO USE

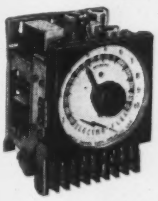
timers and counters



Bulletin 110
20 TURN DIAL RESET TIMER



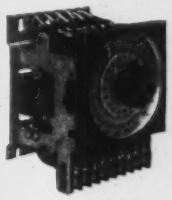
Bulletin 120
SINGLE DIAL RESET TIMER



Bulletin 150
ELECTRONIC RESET TIMER

Bulletin 170
TIME DELAY RELAY

Bulletin 320
ADJUSTABLE REPEAT CYCLE TIMER



Bulletin 720
AUTOMATIC RESET COUNTER

Now in stock for immediate delivery

To better serve your needs without delay, EAGLE now makes available the above Timers and Counters for immediate delivery direct from stocks of EAGLE Representatives in principal cities from coast to coast. See your local phone directory for name and location of your nearest EAGLE Representative. He will be happy to make recommendations and help you engineer your TIME-COUNT problems.

Write EAGLE SIGNAL COMPANY, Dept. IC-959, Moline, Illinois, for descriptive Catalog 351 showing EAGLE'S line of popular TIME-COUNT Controls.

EAGLE SIGNAL COMPANY
A DIVISION OF THE GAMEWELL COMPANY
MOLINE, ILLINOIS

MANUFACTURERS OF THE MOST COMPLETE LINE OF INDUSTRIAL TIME-COUNT CONTROLS

CIRCLE 14 ON READER-SERVICE CARD

trends

College and university labs may receive $100 million for research in fiscal 1959 from Dept. of Defense. Navy—$43 million; Air Force—$35 million; Army—$20 million.

Transistor market (in millions of units) is predicted by J. T. Parry of Hoffman Electronics as follows:

Year	1957	1958	1959	1960	1961	1962
Total	28.7	57.0	125.0	185	240	290
Silicon	1.4	3.2	7.0	15	32	69

The 1958 total of 57 million units had factory value of $112.8 million. Two most important applications of silicon transistors at present are computers and missiles. Ten firms now manufacture silicon transistors; six others have development programs.

70,000 mathematicians, including 10,000 with doctoral degrees, will be needed for computer work alone, says Dr. J. Frame of Mich. State U.—yet it is unlikely that there will be 5000 mathematician PhD's by 1960, and most will not be in computer work.

Analysis of BDSA 1954 sales data reveals that 41.39% of the total dollar sales volume for precision optical instruments was oriented to military sales.

At present, 35 ATOMICHRON frequency standards are installed and in daily use in the world. The first nine (Model NAFS) are located at Lincoln Labs Field Station, Ipswitch, Mass.; Griffis Air Force Base, Rome, N. Y.; MIT Atomic Beam Laboratory, Cambridge, Mass.; NRC, Washington, D. C.; Lincoln Labs, Lexington, Mass.; USASRDC, Ft. Monmouth, N. J.; Princeton University. Princeton, N. J.; and Georgia Tech Field Station, Atlanta,Ga.

Electron-tube market is reported by Electronics Div., BDSA, Dept. of Commerce as follows (in millions of dollars):

	1954	1955	1956	1957	1958
TOTAL, ALL TUBES	691	765	791	816	786
POWER & SPECIAL PURPOSE TUBES, TOTAL	152	148	161	185	214
High vacuum tubes	30	31	37	37	39
Gas and vapor tubes	18	17	17	17	18
Klystrons	14	16	21	25	29
Magnetrons	51	42	42	44	50
Forward and backward wave tubes	—	1	2	6	17
Duplexers	7	6	5	6	7
UHF Planar (lighthouse)	6	6	7	13	13
Cathode ray light emitting, storage and camera tubes, excluding TV picture tubes	15	17	19	23	25
Miscellaneous[2]	11	12	11	14	16
RECEIVING TUBES, TOTAL	300	380	390	400	355
TV PICTURE TUBES, TOTAL	239	237	240	231	217

[1] Includes intra-plant and inter-plant transfers.
[2] Includes photo tubes; photo cells; radiation detection tubes; spark gaps; beam deflection tubes; decade counters; electronic switches; mechanical transducers; orbital beam tubes; and vacuum capacitors, switches, and gauges. Excludes X-ray tubes.

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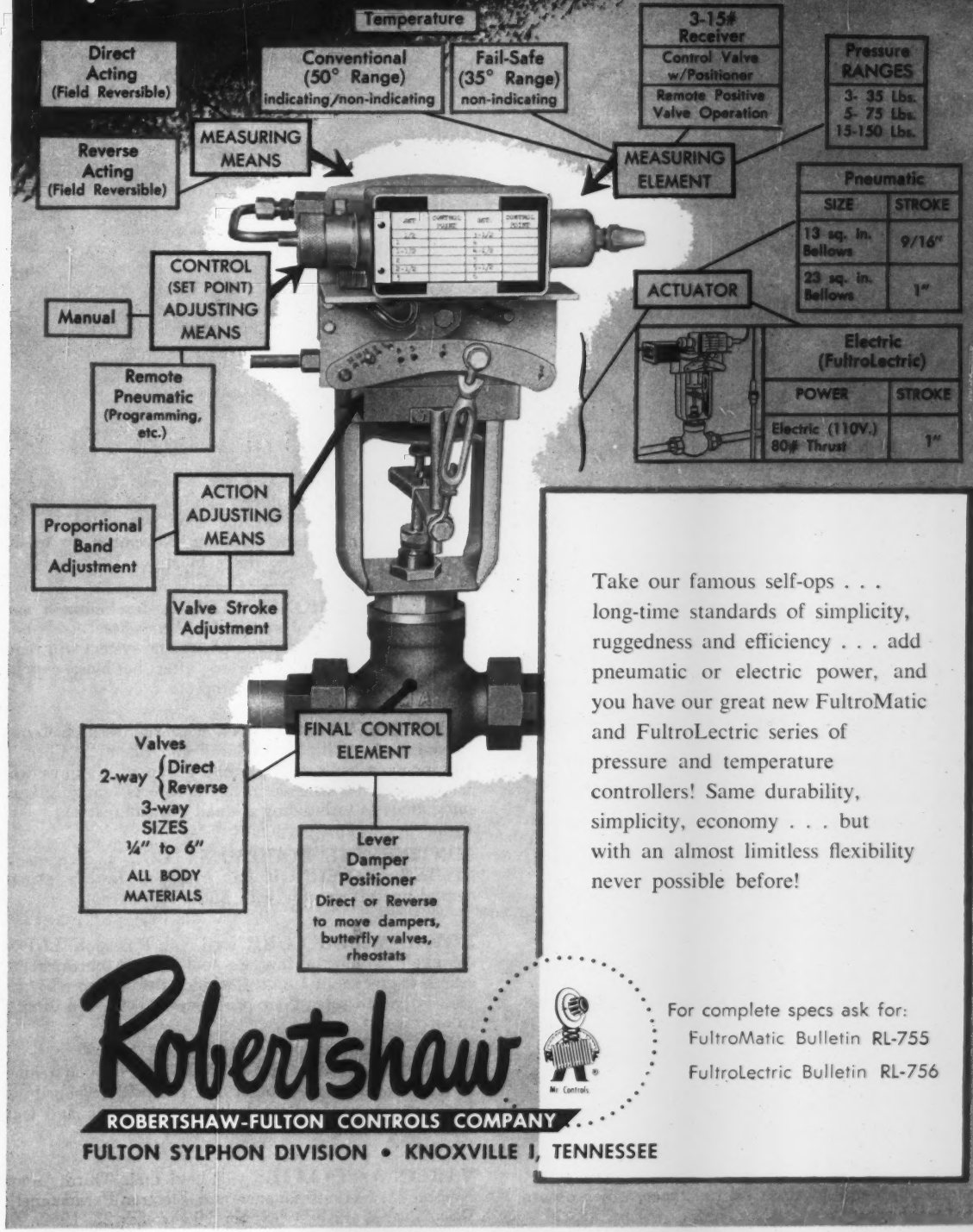
The Greatest Flexibility in Powered Controllers!



Take our famous self-ops . . . long-time standards of simplicity, ruggedness and efficiency . . . add pneumatic or electric power, and you have our great new FultroMatic and FultroLectric series of pressure and temperature controllers! Same durability, simplicity, economy . . . but with an almost limitless flexibility never possible before!

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Robertshaw

ROBERTSHAW-FULTON CONTROLS COMPANY
FULTON SYLPHON DIVISION • KNOXVILLE 1, TENNESSEE

CIRCLE 15 ON READER-SERVICE CARD

news

Industrial Hydraulics

CHICAGO, ILL.—The Fifteenth Annual Meeting of the National Conference on Industrial Hydraulics will be held at the Sherman Hotel, Chicago, October 22 and 23, 1959. A general session, eleven technical sessions, two luncheons, and a banquet comprise the meeting. Program will be available from R. D. Meade, 3300 South Federal St., Chicago 16, Ill. toward the end of September.

Industrial Electronics

PITTSBURGH, PA.—The Eighth Annual Industrial Electronics Symposium will be held in Pittsburgh, Sept. 30-Oct. 1, 1959, Mellon Institute. Symposium is sponsored by Nat'l Professional Group on Industrial Electronics of IRE and Pittsburgh Section, AIEE. Two-day meeting will have sessions on (1) Transducers and Applications, (2) Model vs Teleological Control, (3) Control Systems Applications and (4) Electronic Data Processing. Program and advance registration data from: Bob Delgado, 954 Brentview Drive, Pittsburgh 36.

A New Russian Method to Measure Small Displacement

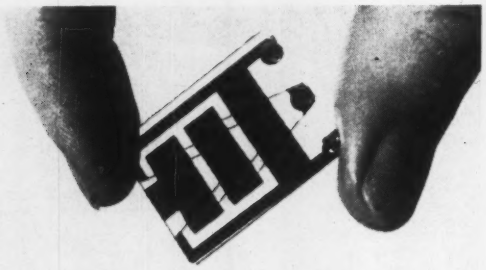
MOSCOW.—*Instrument Construction*, the new Russian magazine, describes a method, developed by A. Yu Gudel, in which the relationship between the thickness of a drop of mercury and its diameter is used to measure small displacement. When compressing the mercury between two plates of quartz, the diameter of the drop increases rapidly, and Gudel found that when decreasing the thickness from 0.010 mm to 0.005 mm the amplification in the corresponding diameters is approximately 1900. Thus a change in thickness of one micron corresponds to a change in diameter of approximately 2 mm.

In the displacement meter described in the magazine the movable bottom plate furnishes the indication, and the setting of the disc diameter is made by a microscope.

Cryotron Switch

CAMBRIDGE, MASS.—Scientists of Arthur D. Little, Inc. recently disclosed at the Solid State Research Conference that they had perfected the first operating six-cryotron circuit in which thin films of tin and lead, vaporized and deposited on glass, operate in liquid helium four degrees above absolute zero (4° K or —450° F). The device makes use of superconductivity, or complete absence of electrical resistance, which occurs at this temperature.

The team, under the direction of Albert E. Slade, found that vacuum-deposited cryotrons offered the advantages of reduction of inductance for greater speed, radical miniaturization, and comparative ease of fabrication. At the present state of the art, the devices already



are a thousand times faster than their wire-wound predecessors and hold promise of speeds on the order of 100 mμsec. The use of masks, or stencils, in the deposition process opens the possibility of automation. A conservative estimate suggests that 2,000 cryotrons could be contained in a cubic inch.

Predictions are that the first superconductive computer, drastically reduced in size and price, will be available in four or five years.

Exposition Postponed

PITTSBURGH—Management for the Fifth International Automation Congress and Exposition has announced postponement of the show scheduled for the New York Trade Show Building, November 16 to 20, 1959. The show will be rescheduled for 1961.

MINNEAPOLIS-HONEYWELL is developing a special automatic control system for Acme Steel Co.'s new blast-furnace-less $33-million plant. The system will regulate oxygen flow to converters after hot-blast cupolas have extracted the iron from the ore.

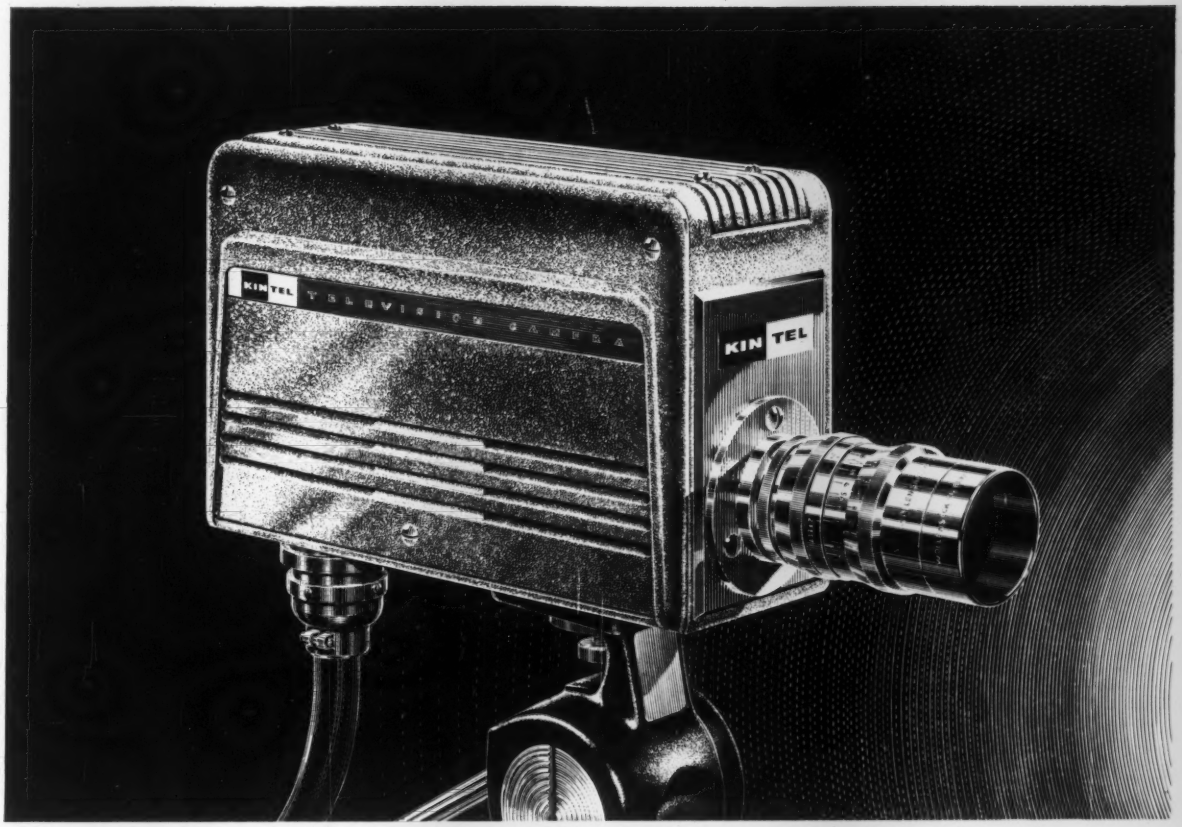
ROBERTSHAW-FULTON's Western Research Center in conjunction with U. S. Borax and Chemical Corp. is sponsoring a Science Explorer's group of 13 boys who need scientific assistance in their projects (ranging from smog analysis to building a small nuclear reactor).

CONTINENTAL EQUIPMENT CO., a division of **FISHER GOVERNOR** has equipped India's experimental nuclear reactor with butterfly valves.

ROYAL McBEE CORP.'s Royal Precision LGP-30 computer is now a favorite tool for 20 chemical research engineers at Union Carbide Olefins Co., who previously had to solve their problems with the aid of slide rules.

NATIONAL SCIENCE FOUNDATION, upon request of the Bureau of the Budget, has accepted responsibility for a program of national data on scientific and technical personnel.

VARIAN ASSOCIATES will hold their Third Annual Nuclear-Magnetic-Resonance and Electron-Paramagnetic-Resonance Workshop October 19 through 23, 1959.



For laboratory performance... in rugged field applications

LOCKHEED AND HUNDREDS OF OTHER FIRMS CHOOSE KIN TEL...THE QUALITY-LEADER IN CLOSED CIRCUIT TV

Hundreds of leading firms specify KIN TEL Closed Circuit TV Systems when they *can't* compromise on quality...when they *must* observe operations that are tedious, difficult, or even impossible for men to watch.

Why a KIN TEL System? First, it is designed to work continuously, faultlessly even under extreme environmental conditions. Second, it is fully automatic...provides 1% linearity and continuous self-adjustment for light-level variations up to 2000:1. Third, it features crisp, photoprint picture quality–*twice* the resolution of the best home TV reception.

This basic TV system, consisting of camera, camera control, and receiver, is surprisingly low in cost, easy to operate, and simple to maintain. A complete line of housings and accessories permits observation of nearly every kind of operation, under all kinds of conditions.

Nationwide factory-trained engineering representatives can show you how a KIN TEL TV System can be put to profitable use in your business. Write direct for TV catalog 6-103 and the name of your nearest representative.

Partial List of KIN TEL Closed Circuit TV Customers

GENERAL MOTORS
E. I. DUPONT DE NEMOURS
WESTINGHOUSE
EASTMAN KODAK
PHILLIPS PETROLEUM
LOCKHEED
CONVAIR
DOUGLAS
U. S. STEEL
LOS ANGELES DEPT. OF WATER & POWER
RAYTHEON
AMERICAN POTASH AND CHEMICAL
SANDIA CORPORATION
JOHNS HOPKINS UNIVERSITY
SHELL DEVELOPMENT
PHILCO
SAN FRANCISCO NAVAL SHIPYARD
PACIFIC TELEPHONE AND TELEGRAPH
REDSTONE ARSENAL
MELLON INSTITUTE

KIN TEL manufactures closed circuit TV and electronic instruments for measurement and control. Representatives in all major cities.

KIN TEL
A DIVISION OF
COHU
ELECTRONICS, INC

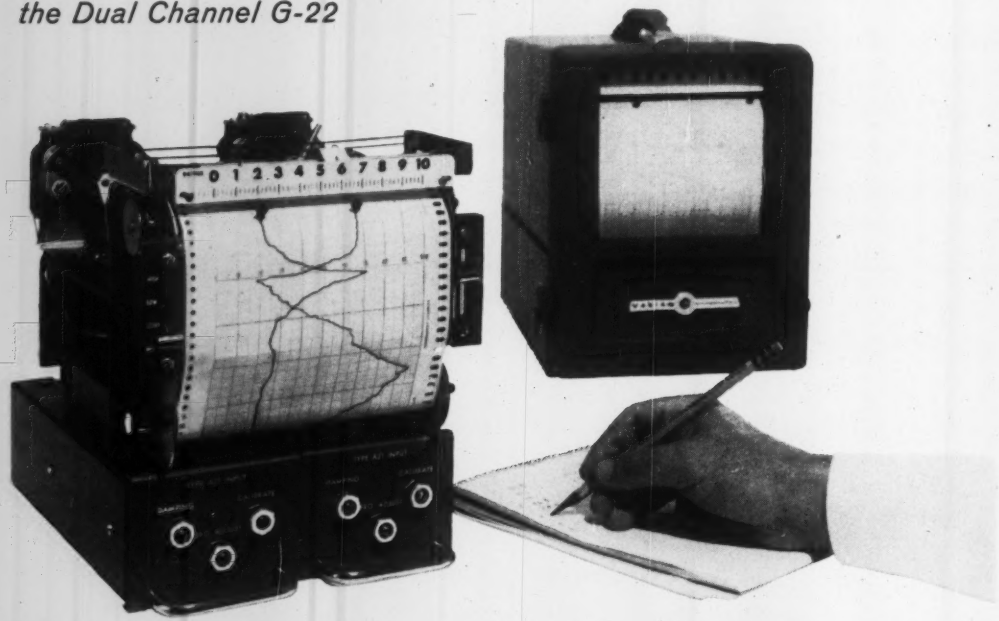
5725 Kearny Villa Road, San Diego 11, California • BRowning 7-6700

CIRCLE 16 ON READER-SERVICE CARD

Announcing the newest

VARIAN Potentiometer RECORDER

the Dual Channel G-22



MOST COMPACT AND PORTABLE

TWO-CHANNEL RECORDER

Size and price need no longer limit the use of two-channel recorders. The Varian G-22 is the least expensive servo-operated two channel available—and also the most compact. It puts two time-correlated variables onto one chart of 5-inch calibrated width.

The Varian G-22 is of completely modular design—and a truly versatile instrument. Plug-in input chassis are interchangeable to provide various recording characteristics. Chart motors are easily changed for additional speeds. Range is adjustable from 0-9 mv to 0-100 mv on the basic input chassis. Zero can be set anywhere across the chart. And being a potentiometer recorder, the G-22 has the necessary sensitivity to serve a wide variety of recording needs.

FEATURES

- Potentiometer measuring circuit thousands of times more sensitive than a galvanometer.
- Quickly interchangeable plug-in input chassis provide various recording characteristics.
- Two-speed gear shifter standard; four chart speeds available by dual motor option. Choice of speeds from ⅛ in/hr to 8 in/min.
- Modular construction throughout; permits rapid removal of subunits with a screwdriver.
- Panel mount or portable versions available. Total weight is 35 pounds.
- 1 % limit of error and one second full-scale balancing time.
- Cast aluminum case and box frame structure provide ruggedness.
- Direct shaft connection between servo motor and potentiometer provides positive drive and allows space for optional accessories.
- Accessories include retransmitting slidewires, event markers, and alarm contacts.
- Capillary pens and large reservoirs provide reliable inking.
- **Only $975 complete.**

For full information, write the Instrument Division

VARIAN associates

PALO ALTO 27, CALIFORNIA

CIRCLE 17 ON READER-SERVICE CARD

THE BIG LOOK

2½-inch size

ACTUAL SIZE—Although they look bigger, these a-c and d-c units are actually 2½- and 3½-inch sizes. Mounting is interchangeable with JAN, MIL and ASA (round) specifications. ***Widest range of scales and face-plate colors are available.***

3½-inch size

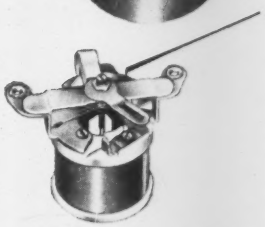
General Electric small panel meters

BIG LOOK styling of General Electric's new small panel meters adds *functional beauty* to your products and equipment. Distinctive design creates the illusion of bigness, yet these new meters fit into the same panel space as old style meters. You get big border-to-border scale . . . *modern, clean-line design* . . . *your choice of seven attractive colors* . . . and widest selection of scales.

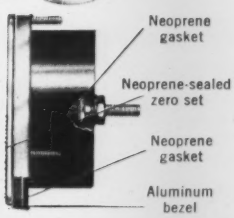
Up to 28% longer scales allow accurate readings. Tough neoprene gaskets provide *complete protection* of internal parts and movements from dirt, dust or water. Best of all, General Electric BIG LOOK meters are *competitively priced.* And you can plan on *fast delivery*, too, from a national network of authorized stocking distributors and G-E Apparatus Sales Offices.

Let G.E.'s BIG LOOK in panel meters help you improve the appearance and reliability of your equipment at low cost. Get the full story. Just contact your G-E Apparatus Sales Engineer, or write for bulletin GEA-6678, Sect. 593-303, General Electric Co., Schenectady, N. Y.

SELF-SHIELDED CORE-MAGNET, **used in d-c milliammeters below 5 MA and all microammeters, permits mounting of meters on magnetic or non-magnetic panels without special calibration.**



ALL A-C METERS **utilize moving-iron mechanisms—plus magnetic damping to settle the pointer quickly and accurately.**



COMPLETELY SEALED CASES **protect internal parts of instrument from harmful contaminants. Even zero-set is sealed with a neoprene O ring.**

Progress Is Our Most Important Product

GENERAL ELECTRIC

CIRCLE 18 ON READER-SERVICE CARD

Announcing Epsco's **NEW**

DVOM

A MAJOR ADVANCE IN DIGITAL VOLT-OHM METERS

⅓ ACTUAL SIZE

FULLY TRANSISTORIZED

No Stepping Switches • No Relays

● **VERSATILE** accurately measures both resistances and AC-DC voltages and counts external events, too! Directly drives printers, punches and memory storage units and can be directly used as a bi-directional telemeter.

● **FAST** less than 2 millisecond reading time . . . up to 100 completely independent measurements per second for any system use.

● **EASY TO READ** in-line, in-plane visual display . . . lamp life up to 10,000 hours . . . numerals 1⅛ inch high . . . automatic indication of polarity, decimal point and mode of operation

True dependability and versatility have at long last come to digital volt-ohm meters in EPSCO'S new DVOM. Fully transistorized...adjustment-free...no stepping switches or relays. Provides precise numerical measurement of AC-DC voltages, resistances . . . fast, accurate visual or printed quality control data . . . high-speed data acquisition for direct print-out or storage...remote indication and data transmission over a single line. Compact, lightweight, portable — also for rack-mounting. Write for Bulletin 95801, Epsco, Inc., Equipment Division, 275 Massachusetts Ave., Cambridge, Mass.; in the West: Epsco-West, 240 East Palais Rd., Anaheim, California.

DVOM price $1,475

Ask for a demonstration.

Epsco

First in data control

CIRCLE 19 ON READER-SERVICE CARD

NEWS—CONTINUED

BAILEY METER instruments and controls will be used predominantly for the nuclear instrumentation and safety systems in Consolidated Edison's Indian Point Nuclear Power Station, for which GE's Atomic Power Equipment Dept. has been selected to design and manufacture the equipment.

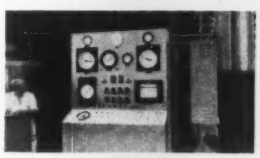
HAGAN's pneumatically-controlled weighing and conveying system for handling additions of limestone, burnt lime, and pellets to the oxygen steel-making vessel during the progress of the heat, has been in satisfactory operation for one year by one of the largest Midwest users.

A BENDIX-AVIATION G-15 computer, put to work 250 miles away, has saved the engineering firm in charge of land surveying for the new Barkley Dam a mimimum of 3000 man-hours.

Formation of an **INTERNATIONAL FEDERATION OF INFORMATION PROCESSING SOCIETIES (IFIPS)** will be the result of the UNESCO-sponsored International Conference on Information Processing held in June in Paris. Ratification by the various countries is expected in the first quarter of 1960.

ELGIN METALFORMERS CORP. has built a unique diesel engine test facility at *Socony Mobil Oil Co.'s* Paulsboro, N. J., R&D lab which integrates four previously separated operations. The control console was assembled from standard modular enclosures, panels, and components parts.

Elgin's engine test facility



M-H single-button centralized control

MINNEAPOLIS-HONEYWELL has installed a system at Arborite Co., Ltd., Montreal, which at the touch of a single button provides centralized control of entire heating, curing, and cooling cycle of a completely automatic multi-platen press for the production of laminated plastic.

An **IBM** RAMAC 305 computer has been placed in operation by Bergen Drug Co. to monitor an inventory of more than 25,000 items.

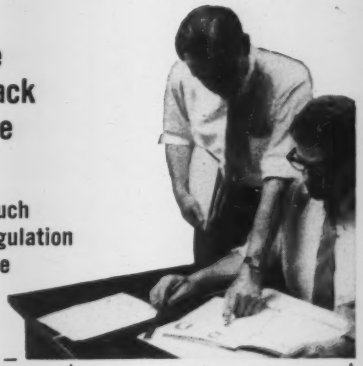
WASHINGTON UNIVERSITY, St. Louis, reports development of the first matric calculus computer by *Prof. Pierre M. Honnell* and his doctoral students. It works with general matrix equations as well as with differential, and some integral, calculus equations.

NATIONAL SCIENCE FOUNDATION has published a survey of Russian scientific literature, listing 76 Soviet journals now available in English. Soviet scientific materials are regularly listed in the Monthly Index of Russian Accessions, published by the Library of Congress and available from the Superintendent of Documents of the Government Printing Office.

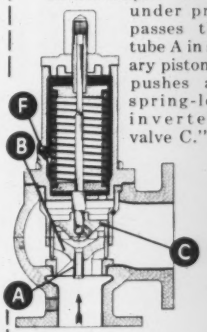
POLYTECHNIC RESEARCH & DEVELOPMENT CO. received an Army Ordnance contract for $966,700 for precise calibration of field microwave test equipment.

"How does the Klipfel #135 back pressure valve work?"

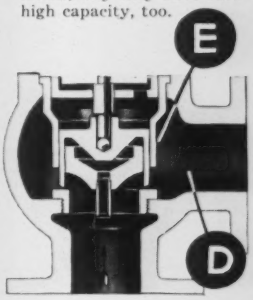
How can it give such close pressure regulation (4% over the entire capacity range)? Here's the story:



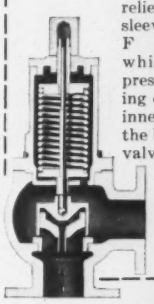
"Controlling inlet pressure and flow in a pipe line is all any back pressure valve does. How *well* it does this is, however, a different story. In this Klipfel Valve liquid under pressure passes through tube A in stationary piston B, and pushes against spring-loaded, inverted-cup valve C."



"When liquid pressure exceeds spring pressure, valve lifts open, letting liquid flow into outlet chamber D. This shows how Klipfel No. 135 Valves give such close regulation; why they have such high capacity, too.



"This is the same back pressure valve, modified to act as a relief valve. As you might guess, relief valves prevent excess pipe line pressures by relieving to the atmosphere. The only difference between the two valves is that the relief valve has no sleeve E and vent F (above)—which prevent pressure from acting downward on inner valve C in the back pressure valve."



"MOST IMPORTANT FEATURE in any back pressure or relief valve (aside from dependability) is smooth, chatter-free opening and closing. Also, relief valves should close tightly, but this isn't so important in back pressure valves."

• **For the complete story of back pressure and relief valves, without cost or obligation, write for Bulletin 454.**

HAMILTON • OHIO **Klipfel** VALVES INC.

Automatic Temperature-and-Pressure-Regulating Valves Since 1902

Float Valves • Temperature Regulators • Back Pressure Valves • Reducing Valves

A DIVISION OF THE HAMILTON-THOMAS CORPORATION

CIRCLE 20 ON READER-SERVICE CARD

EPLAB

PYRHELIOMETER
For the Measurement of SOLAR RADIATION

Eppley Pyrheliometers are used for solar radiation measurements at ninety-eight weather stations in the continental United States, Canada, Alaska, Greenland, Iceland, Caribbean Sea, and the Pacific Ocean. Sixty-two of these stations are under the direction of the United States Weather Bureau.

The Eppley Pyrheliometer was adopted as standard equipment by the Weather Bureau after considerable experimentation. It was found to be the best instrument so far tested by the Bureau.

Used in conjunction with a suitable recorder, the Eppley Pyrheliometer will provide an accurate and reliable record of total solar and sky radiation on a horizontal surface.

Bulletin No. 2 on Request

THE EPPLEY LABORATORY, INC.

Scientific Instruments

2 Sheffield Ave.

Newport, Rhode Island U. S. A.

CIRCLE 21 ON READER-SERVICE CARD

stock report

Further information may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

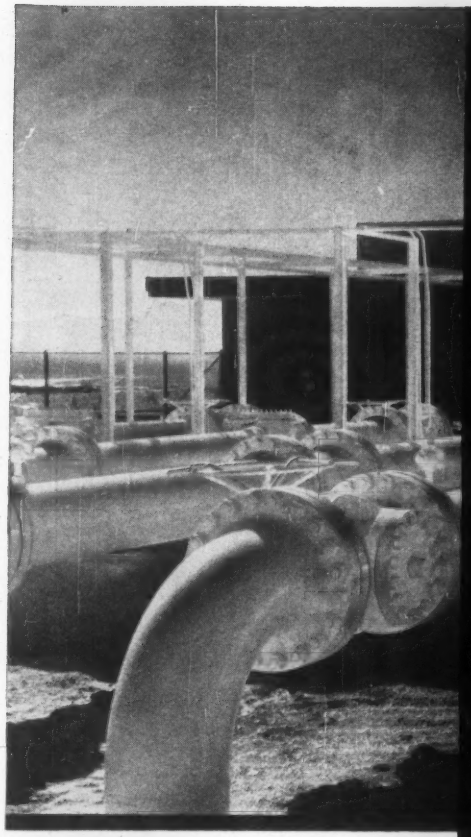
NEW YORK STOCK EXCHANGE
PRICE RANGE FOR 1959 THRU August 14, 1959

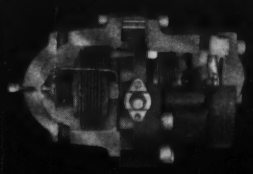
	HIGH	LOW	PRICE AS OF 8-14-59
ACF Industries	56 1/4	47 5/8	55 3/4
Aeroquip Corp.	34 3/4	23 5/8	32 3/4
Allis Chalmers	36 1/2	26 7/8	35 1/2
American Chain & Cable	61 3/4	47 3/4	60
American Machine & Foundry	100	53 1/2	90 1/2
American Machine & Metals	59 3/4	41	50 1/4
American Optical	53 1/2	38 3/8	48
American Tel. & Tel.	89	75 1/2	80 1/4
Ampex Corp.	88 1/4	61 1/4	78 1/2
Bausch & Lomb Optical	40 1/2	27	37
Beckman Instruments	74 3/4	36 1/4	55 3/4
Bell & Howell	74 3/8	58 1/2	61
Bendix Aviation	89	66	73 3/4
Boeing Airplane	46 1/2	32 1/4	33
Bullard	24 7/8	16	19 5/8
Bulova Watch	20 5/8	13 1/2	16 1/2
Burroughs	45 3/4	32 1/4	32 3/8
Carborundum	56 3/4	37 3/8	52 3/8
Cincinnati Milling Machine	47 5/8	38 3/4	43
Clevite	40 3/8	24 3/4	37 1/2
Columbia Broadcasting System	48 3/4	35	43
Consolidated Electrodynamics	45 1/2	33 3/4	37 5/8
Consolidated Electronics	53	33 1/2	42 7/8
Cornell Dubilier	30 1/2	20 3/4	23
Corning Glass	150 1/2	89 3/4	140
Curtiss Wright	39 1/2	27 1/8	30 1/4
Cutler-Hammer	94 1/4	59 1/2	84 3/4
Daystrom	49 3/4	34	40 3/8
Douglas Aircraft	59 3/4	43 1/4	45
Eastman Kodak	97 3/8	75	89 1/2
Eaton Mfg.	90 3/4	56 1/4	83 1/2
Electric Auto-Lite	55	36 1/4	50 3/4
Elgin Watch	14	9 3/4	10 1/4
Emerson Electric	69 7/8	48 1/8	61 1/2
Food Machinery & Chemical	53 3/4	40	53 5/8
Gamewell	39 1/4	27	29 1/4
Garrett	50 7/8	38	46
General Controls	39 1/4	24	30 1/2
General Dynamics	66 1/2	49 3/8	51 1/4
General Electric	84 3/4	74 5/8	81 1/2
General Instrument	38 3/8	16 1/2	25 7/8
General Mills	120 1/2	88 1/4	108
General Precision Equipment	45 1/2	31 1/2	39 3/4
General Railway Signal	39 1/4	33	35 5/8
General Tel. & Elec.	79	60	76 1/8
General Time	104 1/2	35	86 1/2
General Tire & Rubber	83	44 1/8	66 3/4
International Bus. Machines	488	385 1/2	421 1/4
International Tel. & Tel.	45 1/2	28	34 3/4
I-T-E Circuit Breaker	50 1/2	36 5/8	44 3/8
Litton Industries	135 7/8	72 5/8	107 1/2
Lockheed Aircraft	39 3/4	27 1/8	28
Magnavox	70 3/4	48 1/4	63 1/2
Mallory	48 3/4	36 3/8	40
Minneapolis-Honeywell	150	111 1/2	130 1/2
Minnesota Mining & Mfg.	151 1/2	111 1/2	146 1/2
Motorola	130	57 1/2	112
National Acme	63 1/2	52 1/4	58 1/2
National Cash Register	80	58 1/2	58 5/8
Neptune Meter	39 5/8	31 3/4	32 1/4
North American Aviation	52 5/8	38 1/8	39 1/2
Northrop Aircraft	44 3/4	29 3/4	30 1/2
Otis Elevator	83	61 1/2	79 1/2
Philco Corp.	36 3/4	21	25 3/4
Radio Corp. of America	71	43 1/8	63 1/2
Raytheon Mfg.	73 7/8	45	49 1/4
Reliance Electric	60 3/4	42 5/8	58
Rheem Mfg.	25 3/4	18	21 7/8
Robertshaw Fulton	53 7/8	31 5/8	46 1/4
Royal McBee	24 3/8	16	17 1/4
Sangamo Electric	51 1/2	35	40
Siegler Corp.	45 1/8	26 1/4	29
Sperry Rand	28 1/4	21 1/4	24
Square D	36 3/4	26 7/8	36 1/2
Standard Coil Products	23 3/4	14 3/8	16 3/4
Starret (L.S.)	23 7/8	20	20 5/8
Stewart-Warner	62	42 1/2	57 3/4
Telautograph	13 3/8	9	12
Texas Instruments	159 1/2	61 1/4	128 1/4
Thompson-Ramo-Wooldridge	70 1/4	56 1/4	61
Tung-Sol Electric	54 1/4	34 1/8	40 3/4
Underwood Corp.	30 7/8	20 5/8	25 3/4
Union Carbide Corp.	150 1/2	120 1/2	143 7/8
United Shoe Machinery	58 3/8	45 5/8	56 1/8
Wallace & Tiernan	52 7/8	36 1/4	45 3/4
Western Union	43 7/8	29 3/4	38 7/8
Westinghouse Air Brake	38 1/2	30 1/4	31 7/8
Westinghouse Electric	98 3/8	70 1/2	92 1/8
Worthington Corp.	84 1/2	70 1/2	79 1/4

AMERICAN STOCK EXCHANGE
PRICE RANGE 1959 THRU AUGUST 14, 1959

	HIGH	LOW	PRICE AS OF 8-14-59
American Meter	46	38	= 45 1/4
Aro Equipment	29 3/4	22	23 3/4
Barry Controls "B"	26	13 3/4	19 1/2-20 (1)
Belock Instruments	22 7/8	10 3/8	16 7/8
Benrus Watch	9	5 7/8	7 1/2
Breeze Corp.	9 3/8	6 1/4	7
Clark Controller	30 3/8	19 5/8	27 3/8

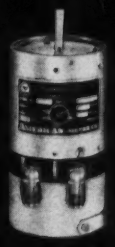
Continued on page 1300





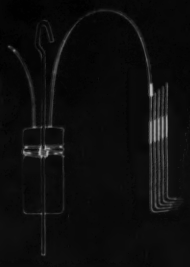
ORIFICE METERS

American-Westcott Dri-flo and mercury manometers in recording, indicating and integrating models—to 5000 psi working pressure.



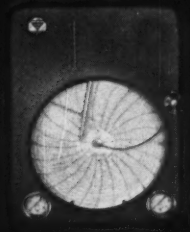
GASCLOK

Gas or air-operated instrument power drive and timing unit for remote installations.



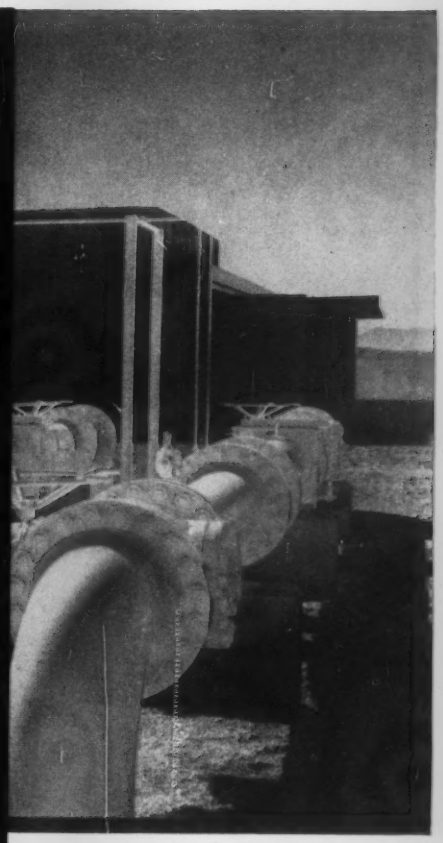
CANNON PENS

Controlled-flow capillary meter pens record up to a full year without refilling—eliminate chart smearing and blurring.



CONTROLLERS

Series A-88 Controllers, Transmitters & Receivers for control of continuous process variables. Telemetering Systems designed to meet your requirements.



RELY ON AMERICAN® INSTRUMENTS FOR YOUR TOUGHEST JOBS

American's complete line of equipment sets the highest standards for accuracy and dependability. Ask your American representative about their applications and advantages for your measurement and control problems.

AMERICAN®
METER COMPANY
INCORPORATED (ESTABLISHED 1836)

GENERAL SALES OFFICE: Philadelphia 16, Penna. • Albany Atlanta • Baltimore • Birmingham • Boston • Chicago Dallas • Denver • Houston • Kansas City • Los Angeles Minneapolis • New York • Omaha • Pittsburgh • San Francisco • Seattle • Tulsa • Wynnewood

IN CANADA: Canadian Meter Company, Ltd., Milton, Ontario Calgary • Edmonton • Montreal • Regina • Vancouver

SUPPLIERS TO THE GAS INDUSTRY for Ironcase, Tinned Steelcase, Aluminumcase and Welded Steelcase Meters American-Westcott Orifice Meters • Instruments • Reliance Regulators • Apparatus • Valves

CIRCLE 22 ON READER-SERVICE CARD

Photos by Robert Yarnall Richie

Designed, engineered and constructed by The Lummus Company, this giant petrochemical complex at Lake Charles, La., has three separate control rooms. The compressor and boiler unit is controlled by 38 Microsen control loops. 141 other loops measure variables to control ethylene processing, and 75 more control the ethylene oxide-glycol unit. Kybernetes data read-out equipment is integrated with Microsen instruments in one of the control rooms.

Over 250 Microsen® loops automate processes at Petroleum Chemicals, Inc. and Calcasieu Chemical Corp.

Microsen Electronic Process Instrumentation measures and controls temperature, pressure, flow, and liquid level in this new $80,000,000 installation. Microsen, the DC control system pioneered by Manning, Maxwell & Moore, Inc., was selected for quality of control and ease of installation.

Standard Microsen instruments are used in cascading. By adding ratio amplification in the output of master Controllers, special variable cascade units are created.

The process boiler installation is unique in the use of electronic instrumentation to control both air and gas supply. A special bipolar accelerating amplifier provides zero output under stable process conditions for the three-element feed-water boiler controls.

If a process upset occurs, the amplifier increases output in the indicated direction to correct the deviation. Amplifier output then decays to zero. Decay time is continuously adjustable within a range of .05 to 5.0 seconds.

Field wiring from Transmitters and Valve Positioners is carried in explosion-proof conduit which terminates in ducts at the rear of the panels in each control room. Wiring from ducts to panel instruments is covered with flexible rubber.

Microsen Electronic Process Controls assure permanent savings. They instantly transmit accurate measurements over long distances – assure process stability and efficiency. The DC signal (1.0 to 5.0 ma) is compatible with practically all data handling, telemetering and computing systems, and with process stream analyzers being developed. Microsen design flexibility anticipates ever-changing needs in process control.

Be certain of closer process control. Step up product quality and quantity. For new plant, new process or revamped old process, automate with the Microsen Electronic System. Learn how profitable it can be. Write for information or call in one of our sales engineers.

MANNING MAXWELL & MOORE INC. MM&M TRADE MARK

MICROSEN ELECTRONIC CONTROLS

A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

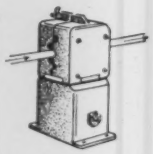
CIRCLE 23 ON READER-SERVICE CARD

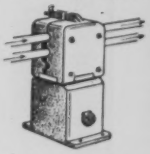
PUMPING IDEAS

POSSIBLE ONLY with a SIGMAMOTOR PUMP

MOVE CORROSIVE LIQUIDS

Material being pumped never comes in contact with pump mechanism. Wave-like motion of steel fingers forces material through Tygon tubing. By changing size of tubing, capacity can be increased or decreased. Pump housing opens for removal and insertion of tubing.



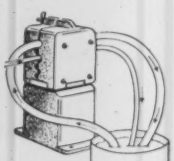


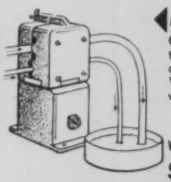
PUMP 2 OR 3 DIFFERENT LIQUIDS SIMULTANEOUSLY

Some models will accommodate up to four tubes so that four different liquids can be passed through the pump at one time without danger of contamination.

FEED AND MIX

One or more tubes can be feeding material to a mix while a larger tube is recirculating the liquid to produce agitation and thorough mixing. Viscous materials can be pumped without danger of gumming or plugging. Remove tube and pump is clean.





METER ADDITIVES

One or more additives can be pumped to a solution in the exact amount desired by selecting the correct size of tubing and regulating pump speed. Various controls can be incorporated to close valves ahead of pump.

Capacities from 0.5 cc. per min. to 4.5 G.P.M.

Write for complete information on sizes and capacities.

SIGMAMOTOR, INC.

49 N. Main Street • Middleport, N. Y.

CIRCLE 24 ON READER-SERVICE CARD

American Stock Exchange: *Continued from page 1296*

Clarostat Mfg.	10 1/4	4	7 3/4
Clary Corp.	10 7/8	5 3/4	8 1/4
DuMont Laboratories	9 7/8	6	6 7/8
Dynamics Corp. of America	12 3/4	4 5/8	10
El-Tronics	2 1/4	1	1 3/4
Fairchild Camera & Instrument	205	50 3/4	148
General Transistor	45 3/8	29	36 1/2
Globe-Union	27 3/4	20 1/4	25 3/8
Hazeltine Corp.	33	25 1/2	26 1/2
International Resistance	22 3/4	7	15 3/4
Lear Inc.	19 1/4	9 1/8	15
National Research	39 1/2	15 3/8	24 1/8
New Haven Clock	5 3/8	1 1/2	3 1/8
Nuclear Corp. of America	4 1/4	1 3/4	2 1/4
Philips Electronics, Inc.	50 1/4	23 1/2	40 1/4
Pneumatic Scale	67	32	45
Servo Corp. of America	43 1/2	14 5/8	26 1/2
Servomechanisms	18 1/4	9	12 1/8
Statham Instruments Inc.	43	23	29 3/4
Victoreen Instrument Co.	19 7/8	6 7/8	15
Waltham Prec. Instrument Co.	4 3/8	1 1/8	2 5/8
Electronics Corp. of America	16 7/8	9 1/2	9 3/4

1) Not traded - Bid and Asked

OVER THE COUNTER

	QUOTATION AS OF 8/14/59 BID	ASKED
Aerovox Corp.	10 5/8	11 3/4
Aircraft Radio Corp.	54	--
Argus Corp.	40 1/4	41 1/4
Black Sivalls & Bryson Inc.	24	24 3/4
Eitel McCullough (W.D.)	23 1/8	23 5/8
Electro Instruments	34	37
Electronics Associates	36	38 1/2
Erie Resistor Corp.	8 1/2	9
Fisher Governor Co.	18 3/4	19 3/4
Foxboro Company	59	61 3/4
Ginnini Controls	24 1/2	26
Hagen Chemicals & Controls	29 1/2	31
Industro Transistor	7 5/8	8 1/4
Liquidometer Corp.	7 1/4	8 1/2
W. L. Maxson	11 7/8	12 1/2
Penn Controls	24 1/4	24 1/4
Speer Carbon, Inc.	21 1/2	23
Sprague Electric	54	56
Taylor Instruments	34	35 1/2
Telecomputing Corp.	10 1/4	11 3/8
Topp Industries	12 1/2	13 1/4
Varian Associates	30	32 1/2
Vitro Corp. of America	14	14 1/2

READ any surface temperature with Alnor® PYROCON

Equipment...material...metallic or non-metallic...flat, curved... revolving or stationary—you can read every surface temperature accurately in less than 3 seconds!

Compact, complete in precision design, this rugged instrument assures highest standards of speed, accuracy and dependability.

Alnor Portable Pyrocons come in scale ranges to 2000° F., with thermocouples for every application. You'll find full details on the Pyrocon exactly suited to your operations in Bulletin 4257. Send for your copy now. Write: Illinois Testing Laboratories, Inc., Room 518, 420 N. LaSalle St., Chicago 10, Ill.

Alnor

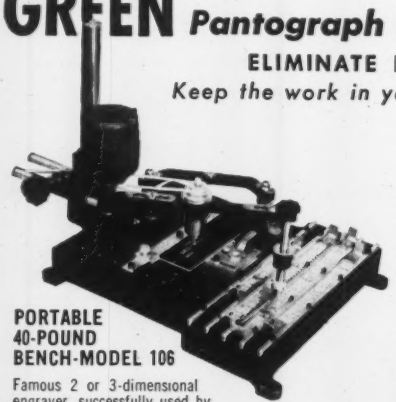
PRECISION INSTRUMENTS FOR EVERY INDUSTRY

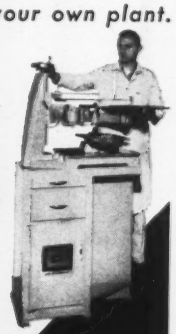
CIRCLE 25 ON READER-SERVICE CARD

GREEN Pantograph Engravers

ELIMINATE DELAYS!

Keep the work in your own plant.





PORTABLE 40-POUND BENCH-MODEL 106

Famous 2 or 3-dimensional engraver, successfully used by thousands, features 5 positive, accurate pantograph ratios. Versatile ball bearing spindle has three speeds up to 14,000 rpm; height of pantograph and position of cutter are continuously adjustable; one copy carrier (supplied) accepts all standard master type sizes.

The Model 106 has proven incomparable for speed and accuracy . . . yet reasonably priced.

Cutter grinders, rotary tables, master letters, compound slides, name plates and all required accessories. For complete information, write to

MODEL D2 HEAVY-DUTY 2-DIMENSIONAL

- 575 pounds — rigid, sturdy, precise
- Vertical adjustment of copy table automatic with Pantograph
- Unobstructed on three sides to take large work
- Micrometer adjustment for depth of cut
- Ball-bearing construction throughout
- Super-precision ball bearing spindle
- Spindle speeds up to 26,000 rpm for engraving or machining modern materials
- Ratios 2 to 1 to infinity
- master copy area 25" x 10"
- Vertical range over 18"

GREEN INSTRUMENT COMPANY, INC.

383 PUTNAM AVENUE, CAMBRIDGE 39, MASS.

CIRCLE 26 ON READER-SERVICE CARD

NO MOVING PARTS

Designed to indicate media level changes through simple differential capacitance measurement, the new Robertshaw Level-Tel 154 contains no moving parts to clog, wear or jam.

SIMPLE TWO-STEP CALIBRATION

Only two quick, non-interacting adjustments are necessary to calibrate the new Level-Tel 154.

ANTI-FOULING PROBES

Self-cleaning Teflon probe assemblies remain free of deposit build-up, are unaffected by most cohesive substances.

Built to handle the Tough Jobs!

New Robertshaw CONTINUOUS LEVEL INDICATOR

REMOTE INSTALLATION

Over 200 ft. cable length permissible between probe and transmitting unit—virtually unlimited cable span between transmitter and indicator unit.

WIDE TEMPERATURE RANGE

Detector circuitry operable in temperature environments from −30° to +212°F. Teflon insulated probes from −325°F to +350°F, Uninsulated probes up to 850°F.

HIGH ORDER LINEARITY

Unique dectector circuitry permits system linearity consistent with demanding process control requirements.

BUILT-IN TEST CIRCUITRY

Functional system checkout and calibration are simply accomplished by depressing a test circuit button on the control panel indicator.

SIMPLE MAINTENANCE

Printed circuit wiring and plug-in provision for critical components assure minimum maintenance time.

SET POINT CONTROL

High and low level indicator set points adjustable at control panel.

The Level-Tel 154 is a precise, continuous reading level indicating system consisting of a probe detector, transmitter, and indicator. The probe condulet houses a miniaturized capacitance bridge circuit, energized by a regulated Hartley oscillator in the transmitter. In operation, the probe detects media level change as a change in capacitance, unbalancing the capacitance bridge. This out-of-balance condition is fed to the indicator via the transmitter as a DC signal proportional to the level change.

The new Level-Tel 154 is ruggedly designed for accurate operation. It may be used with nearly all liquids, slurries, powders and granular solids. Virtually insensitive to temperature and pressure extremes, the system functions reliably under difficult conditions, i.e., interface, mass measurement, corrosive materials, food processing, cryogenic liquids, combustible substances, and abrasives. It is available in either explosion proof or water tight housings. Let the modestly priced Level-Tel 154 start saving you money now! Write for Bulletin RF-5915 and the address of our nearest technical field representative.

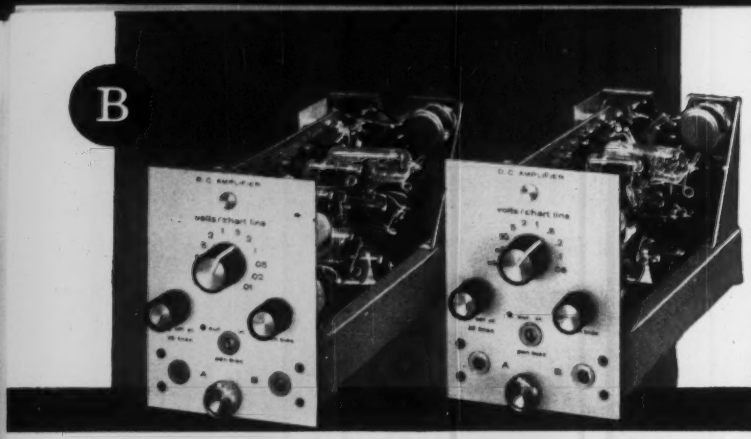
ENGINEERS! *Dynamic growth offers expanding opportunities to qualified EE's and ME's. Send resume to R. A. Sweeney.*

Robertshaw CONTROLS

AERONAUTICAL AND INSTRUMENT DIVISION

SANTA ANA FREEWAY
AT EUCLID AVENUE
ANAHEIM,
CALIFORNIA

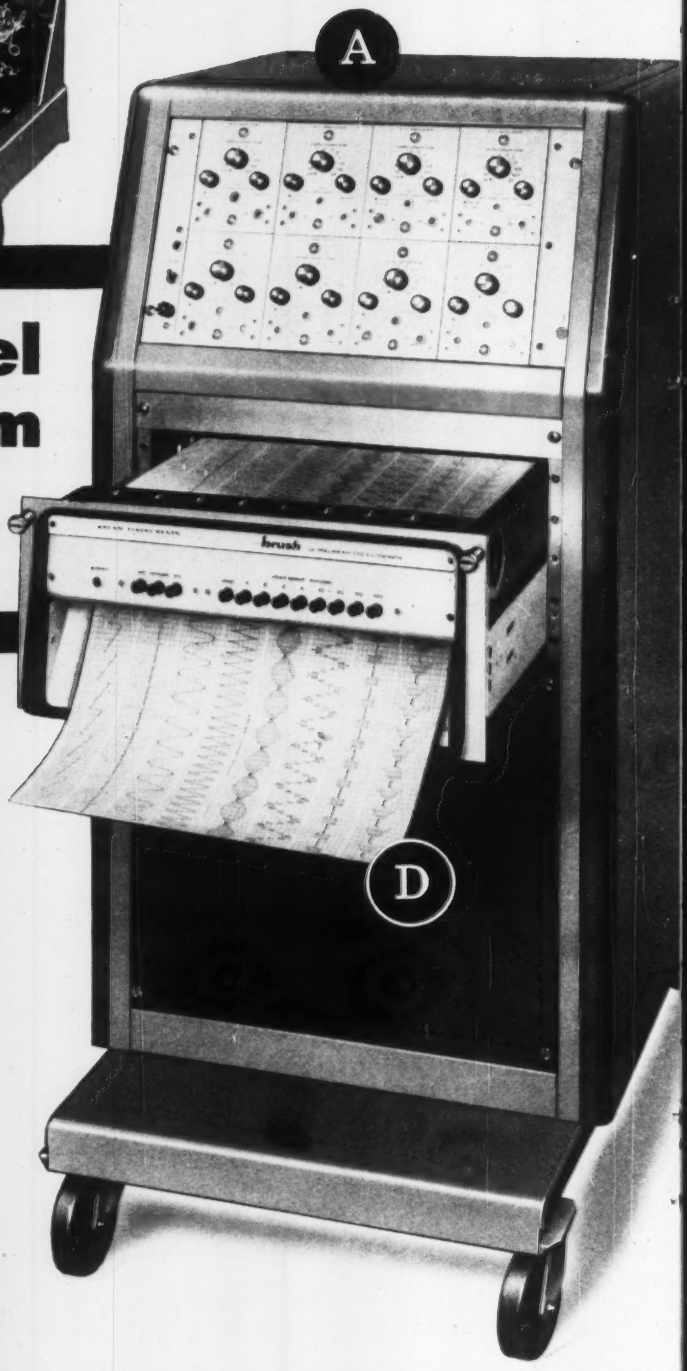
CIRCLE 27 ON READER-SERVICE CARD



Brush 6-8 channel recording system

RECTILINEAR . . . COMPACT

PRECISE . . . SIMPLIFIED!



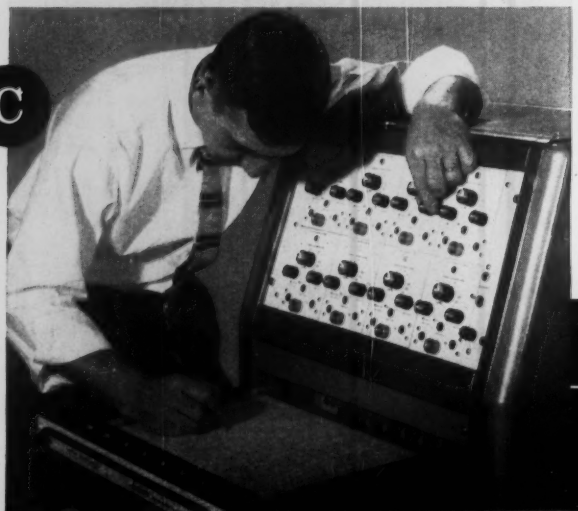
THE new Brush 6-8 channel recorders are designed to give highest reliability and preciseness to readouts for telemetry, computer, ground control and other data gathering systems—with a maximum of simplicity.

A **Complete 6 or 8 channel system** includes slide mounted oscillograph—signal conditioning amplifiers—requires only 20″ of rack height.

B **Interchangeable plug-in signal conditioners.** In addition to amplification, four important functions are provided: high input impedance, zero suppression, attenuation and calibration.

C **"Pull-out" horizontal writing table** permits convenient annotation, reading and control —without removing chart paper or turning off recorder.

D **Rectilinear presentation** gives clear, uniform and reproducible traces for simplified analysis and interpretation. Excellent resolution at all amplitudes and recording speeds.



For further details or application assistance, contact your Brush factory branch or engineering representative.

CIRCLE 28 ON READER-SERVICE CARD

brush INSTRUMENTS

DIVISION OF

37TH AND PERKINS — CLEVITE CORPORATION — CLEVELAND 14, OHIO

IRC

Compu-tran®

PRESSURE TRANSMITTER

This unit was especially designed to extend the uses for a reliable pressure transmitter by lowering the cost. Hundreds in use in critical control systems for missile fuel unloading and nuclear reactors.

Linearity: ±0.5%
Hysteresis: 0.5%
Resolution: 0.2 to 0.4 (depending on resistance range)

- Easily adaptable to provide direct pressure indication or recording using standard electrical receivers.
- Rugged, frictionless, long life precision Potentiometer measuring element—available silicone oil filled, shock resistant to 15 G's.
- Adaptable to convert standard pneumatic process control signals (3 to 15 psi) to equivalent electrical signals for electric data handling system, alarm or long distance transmission.

NEW ZERO-SETTING PRESSURE TRANSMITTER

MEASURES DIFFERENTIAL AND ABSOLUTE PRESSURES

HIGH RELIABILITY—HIGH ACCURACY

EXCELLENT FOR INDUSTRIAL PROCESS APPLICATIONS AND MILITARY TESTING

May be zero-set with a screw-driver for any environmental situation or to obtain zero output for any pre-set differential.

Ranges: 0-100 thru 0-5000 psi static pressure.

High Accuracy: ±0.25%, infinite resolution.

High Reliability: Frictionless magnetic pickoff.

Input: 110V or 6.3V AC adaptable to other voltages and frequencies.

Output: 10 to 100 MV to 5 volts. AC or DC. **Temperature Compensated.**

DISPLACEMENT TRANSDUCER

The IRC Displacement Transducer offers higher sensitivity and better linearity. Especially suited to military applications. High resistance to moisture and shock. Wide range of standard and subminiature sizes with temperature ranges up to 1200°F.

No longer are weak outputs a problem in the application of Differential Transformers.

Better Linearity: 0.1%.

Better Sensitivity: 2.0MV/Volt input/mil @ 60 cycles.

Precision and complete interchangeability assured by close quality control during every step in manufacture.

Special designs for:
120V inputs and up to 50V outputs.
Zero Temperature coefficients.
Power outputs up to 1 watt.

Reliability with the Right Price Tag

FOUND!...

a reliable source for transducers

The word is spreading that there is a dependable source for pressure and displacement transducers—IRC Compu-Tran®. This news is especially welcome because IRC brings to the field a long, successful experience in producing precision equipment. The result is products of sensitivity, linearity, and reliability at previously unheard of savings.

If you design instruments for missile ground control equipment, missile guidance systems, wind tunnels, nuclear reactor cooling fluid controls, controls for the industrial process industries, jet engine controls, precision gaging and weighing devices or any other instruments requiring pressure or displacement transducers, you will want to check IRC Compu-Tran units. Write for one or all of the following bulletins: Pressure Transmitters, Bulletin R-1c; Zero-Setting Pressure Transmitters, Bulletin R-11; Displacement Transducers, Bulletin R-3.

IRC®

International Resistance Company

COMPUTER COMPONENTS DIVISION, Dept. 454, 401 N. Broad St., Phila. 8, Pa.

In Canada: International Resistance Co., Ltd., Toronto, Licensee

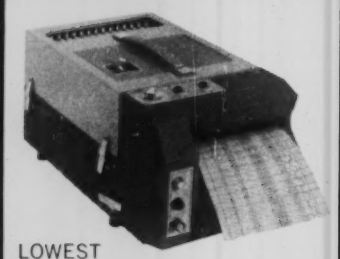
CIRCLE 29 ON READER-SERVICE CARD

NEW !

The 603-607 and the 621 series of direct recording oscillographs, the newest in Midwestern's **EXPANDED** line of precision electronic test data instruments, are the results of years of proven leadership in the field of oscillography. Write for complete brochures and performance information.

UNEQUALLED PERFORMANCE!

603 & 607 SERIES D/R OSCILLOGRAPHS — 50 traces — 12" record — 20 record speeds (.071 to 173 ips) — 6,000 cps flat response.



LOWEST COST!

621 SERIES D/R OSCILLOGRAPHS 14 traces — wide range of record speeds — 6,000 cps flat response.

IF YOU NEED . . .

- Oscillographs
- Galvanometers
- Amplifiers
- Bridge Balance Units
- Discriminators
- Voltage Controlled Oscillators
- Magnetic Tape Recorders
- Power Supplies
- Current Sources
- Data Repeaters
- Servovalves
- Proportional Solenoids
- Torque Motors
- Servo Amplifiers
- Precision Analog Recording Systems
- Aircraft Data Acquisition Recorders
- Complete FM Ground Station Telemetering Systems

WRITE: P. O. Box 7186 / Tulsa, Okla. **TWX:** TU 849
CALL: Riverside 7-1331 **WIRE:** FCB: FAX

MI MIDWESTERN INSTRUMENTS
41st & SHERIDAN ROAD / TULSA, OKLAHOMA

also manufacturers of Magnecord fine tape recording instruments

CIRCLE 30 ON READER-SERVICE CARD

events

Sept. 30-Oct. 1
Eighth Annual Symposium on Industrial Electronics, Pittsburgh, Pa., sponsored by PGIE-IRE and AIEE; contact Bob Delgado, 954 Brentview Dr., Pittsburgh 36, Penna.

October 5-7
Fifth National Communications Symposium, sponsored by IRE Professional Group on Communications Systems, Hotel Utica, Utica, N. Y. For information write C. W. Gordon, 1403 Bedford St., Rome, N. Y.

October 7-9
1959 National Symposium on Vacuum Technology, Sheraton Hotel, Philadelphia, Penna. For information write C. B. Willingham, American Vacuum Society, Box 1282, Boston, Mass.

October 12-14
National Electronics Conference, cosponsored by Illinois Institute of Technology and two technical societies and two universities, Hotel Sherman, Chicago, Ill.

October 13-16
Midyear Meeting of Laboratory Apparatus and Optical Sections, The Cavalier, Virginia Beach, Virginia. For information write Nick Geannopulos, SAMA, 20 N. Wacker Drive, Chicago 6, Ill.

October 13-16
Midyear Meeting of Recorder-Controller Section, Seaview Country Club, Absecon, N. J. For information write Nick Geannopulos, SAMA, 20 N. Wacker Dr., Chicago 6, Ill.

October 14
IRE Medical Electronics Professional Group Meeting on Modern Analytical Methods For Evaluating Cardio-Vascular Function, University of Penna. For information write Helen B. Yonan, Moore School, University of Penna., 33rd & Walnut Sts., Phila., Pa.

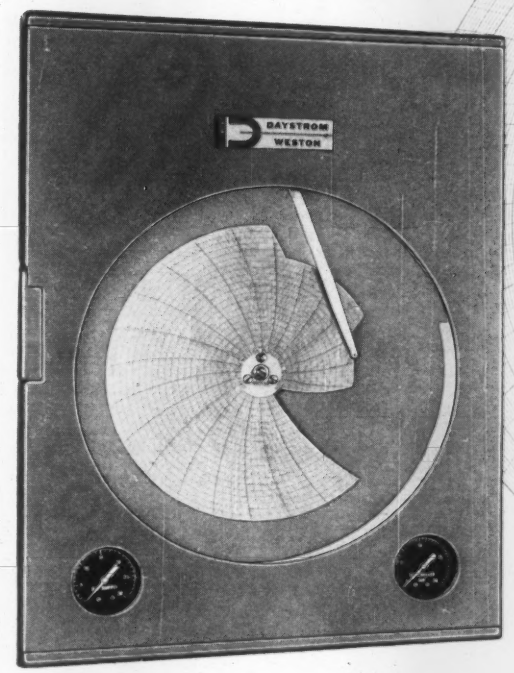
October 21-23
Annual Meeting of Society For Experimental Stress Analysis, Pick Fort Shelby Hotel, Detroit, Mich. For information write Ray A. Gallant, SESA, P.O. Box 168, Central Square Station, Cambridge 39, Mass.

October 22-23
15th National Conference On Industrial Hydraulics, Sherman Hotel, Chicago. For information write Ray D. Meade, Technology Center, 3300 S. Federal, Chicago 16, Ill.

October 25-27
Fluid Controls Institute Fall Meeting, Seaview Country Club, Absecon, N. J. For information write R. McCormick, Automatic Switch Co., Florham Park, N. J.

DAYSTROM-WESTON

presents a new high in control flexibility:



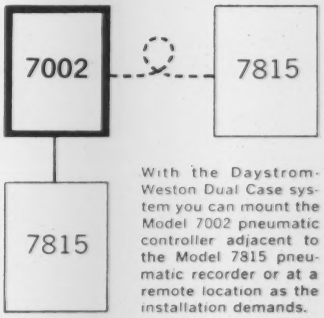
THE 7002 PNEUMATIC PROGRAM CONTROLLER

Here's one control unit that can be readily fitted to practically any programmed process or system. Advanced, accurate, rugged and reliable, the 7002 pneumatic controller comes with either one or two cams, easily cut to your specification; 1-hour to 7-day cam drives.

Stable pneumatic transmission, either single or double, eliminates the need for mechanical rods or levers in feeding information to a partner unit, the Daystrom-Weston 7815 recorder. In fact, these two units are literally made for each other. They can be mounted adjacent to each other or at separate points with equal ease, thanks to cases of special construction.

Dust resistant and moisture-free . . . highly resistant to vibration and shock . . . both units feature Daystrom-Weston's famous unitization — which means unusual simplicity in design and quick accessibility to all parts.

For full information, contact your local Weston representative, or write to Daystrom-Weston Sales Division, Newark 12, N. J. *In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ont. Export: Daystrom Int'l., 100 Empire St., Newark 12, N. J.*



With the Daystrom-Weston Dual Case system you can mount the Model 7002 pneumatic controller adjacent to the Model 7815 pneumatic recorder or at a remote location as the installation demands.

DAYSTROM WESTON

World leader in measurement and control

DAYSTROM-WESTON INDUSTRIAL INSTRUMENTS include a full line of recording and controlling potentiometers with strip and circular charts; mechanical recorders and indicators for pressure, temperature and flow; and non-indicating controllers, both electric and pneumatic.

CIRCLE 31 ON READER-SERVICE CARD

AT LAST!
Instrumentation Amplifiers with no moving parts

✓REDCOR MODEL 361
Differential DC Amplifier

- 200 KC Bandwidth
- 100 megohm input impedance
- 120 db common mode rejection

REDCOR MODEL 259
Operational DC Amplifier

- 200 KC Bandwidth
- 0.001 ohm output impedance at dc
- .03% gain accuracy

REDCOR MODEL 260
Potentiometric DC Amplifier

- 200 KC Bandwidth
- 100 megohm input impedance
- 0.002% gain accuracy

New Transistorized Choppers mean Low Noise...High Reliability

Here is the first line of completely solid state amplifiers with solid state choppers for DC stabilization. These long life amplifiers have integral power supplies and operate over a wide temperature range. They meet the urgent need for wide-band, highly accurate amplification where noise reduction and reliability are of prime importance.

Redcor Development Corp.
Van Nuys, Calif.
Technically Represented By

PACKARD BELL COMPUTER CORP.
1905 Armacost Avenue, Los Angeles 25, California • GR 8-4247

CIRCLE 32 ON READER-SERVICE CARD

CIRCLE 33 ON READER-SERVICE CARD →

Now Available . . . . .

THE AUTOMATIC PLANT

. . . . . technology is ready, but close scrutiny of economics is essential

by W. W. Hopwood
President, Hagan Chemicals & Controls, Inc.

There is no question that most of the hardware for a computer-controlled power or process plant is available today—however, we feel that enthusiasm for this concept has led to a glossing over of the economics of the situation. In addition, as the art of computer control stands today, reliability requirements have been compromised.

We have taken these, and the many other factors which bear on the successful installation of computer control, into consideration in formulating our position, which is: Only as many steps towards complete computer control should be taken as can be justified both technically and economically. Since it is almost impossible to compute the dynamics of a process in advance of its operation, it is only logical to establish a sequence which will permit each step to be tested and justified before the next step is taken. Of course, if a specific situation requires it, the complete package can be installed at once. Here are the steps which we at Hagan feel are reasonable and economically sound:

1. Install a solid state electronic analog control system.
2. Install a solid state electronic scanning-logging data system.
3. Install computer capacity to compute from processed data.
4. Add programming capacity for automatic start-up and shut-down, as well as day by day operation.

Hagan equipment is designed to implement such a program. The Hagan PowrMag analog computer control system, featuring all solid state—magnetic amplifiers, requires minimum maintenance and provides a high degree of reliability and sensitivity with fast response. DC operation at the 1 to 9 volt level permits simple wiring, and the output is ideally suitable for use with the Kybernetes data processing-computing system.

We are ready, at this time, to take the computer control concept as far as the specific operation and management requirements determine.

Kybernetes put into operation at water works system in one day.

The Kybernetes system at an eastern water works *was installed and tested to be operational in one day*. Ninety-two inputs, representing flows, levels and pressures will be displayed as digital values on the main control console. In addition, two typewriters will print out the data for permanent records, and the system permits trend logging of selected variables without interfering with basic scanning. Alarm scanning of all incoming data is also performed automatically. If any variable exceeds preset minimum or maximum values, a visual and audible alarm alerts the operator to take corrective action. Installation test showed that the Kybernetes system was handling all available inputs.

Hagan PowrMag provides high reliability analog computer control

Utilizing magnetic amplifiers as the basic unit, the Hagan PowrMag system represents the most advanced electronic approach to industrial process control. Reliability and long, maintenance-free life are assured in every phase of the system, including inputs, analog computer-controllers, remote control stations and final control elements.

The PowrMag amplifier is a high gain, DC, magnetic amplifier composed of toroidal magnetic cores, windings and silicon diodes . . . all potted in epoxy resin and sealed

in a steel can—thus assuring reliability and long, tamper-proof life. Associated with the amplifier are remote control stations which provide the desired functions, and the whole unit may be mounted on panels up to ¼" thick, occupying only 2½" x 5¼". Utilizing a 1 to 9V DC input and output signal, the system is unaffected by stray AC, information is not deteriorated between measured variable and the final control element. Signals may also be fed to data processors or recorders without interfering with the control action.

PowrMag systems are currently being installed on (1) a 1,250,000 #/hr pulverized coal fired, divided furnace, controlled-circulation steam generation unit for a southern utility, (2) a 2,310,000 #/hr pulverized coal fired, single furnace, single drum, dry bottom reheat type steam generator for a midwest utility, and (3) a 1,700,000 #/hr 2400 psig, 1050°/1000° controlled circulation boiler at an eastern utility.

The Hagan PowrMag system is simple, yet extremely flexible in application. The basic elements are interchangeable, which limits stocking problems. Each element in the system is designed for long, trouble-free life, and adjustment of any loop is easy and exact. Here is the answer to the demand for a sensitive, accurate system with high stability and the utmost in reliability.

Kybernetes data processing system adds new flexibility

The new Kybernetes Series 2000 allows a new approach to the problem of scanning, logging, alarm scanning, computing, optimizing, programming and the many other uses to which data processing systems are put. Of modular construction and utilizing solid state components, the new Kybernetes features optimum reliability allied with such flexibility that a new dimension is added to data processing.

The basic system is a simple logging unit for recording process data on a log sheet or other output device. Because of its modular construction, this basic system can be expanded in both number of points handled and the complexity of the operations performed. This concept is in keeping with the Hagan approach to computer control, since any one or all of these functions may be added as it becomes desirable:

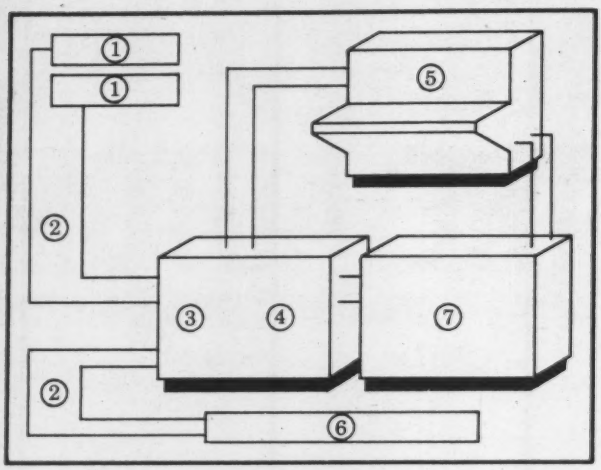
1. Alarm scanning.
2. Printed or visual trend logging of selected variables.
3. Computing or integrating.
4. Automatic programming and optimum setting of control.

With an accuracy of 0.1% on all inputs, the new Kybernetes reflects the simplified design logic which guided its design, and the reliability of all components is assured by the use of solid state devices.

In addition to numerous chemical, refinery and general process installations, a Kybernetes system will process data on the largest steam boiler in the world—a 3,850,000 #/hr unit now under construction at a southern utility.

Maximum usefulness with minimum investment characterizes this development. Field tested and proved, the new Kybernetes data processing unit will provide long, trouble-free operation.

The diagram illustrates a typical installation of Hagan PowrMag units in association with a Kybernetes data system for overall plant control.



1. Transducers convert measured variables into DC electrical signals and transmit to the central analog control computer via two-wire electrical cable. These signals may be recorded or indicated.

2. Two-wire, color coded cable, terminated with vibration-proof taper pin fittings, permits no-lag electric transmission of the measured process even in the largest plant. The system is designed so that the DC signal is, for all practical purposes, unaffected by stray AC potentials. The taper pin connections eliminate all field soldering or terminal box connections.

3. Signals enter plug-in patchboard section of analog computer. Patchboard is arranged to permit interconnection of system in any desired manner by simply moving taper pin connections.

4. PowrMag analog computer control elements are composed of operational magnetic amplifiers. They perform all the required control operations such as addition, subtraction, ratioing, integrating (reset), differentiating (rate), multiplication (proportional band), etc.

5. Remote control stations, located on the central control panel, provide process set point, bias, ratio, and other manually set control operations and have both output and null indicators.

6. Final control elements such as valve positioners, damper operators, saturable reactors, etc., receive the signal from the computer and act on the process function under control.

7. Series 2000 Kybernetes data processing system (see Bulletin MSP 161) can log, scan, trend log, read out, compute and integrate data as received from the PowrMag transducers, thermocouples, and other primary sensing elements. In addition, the Kybernetes digital computations can be used to return set point instructions to the PowrMag analog computer to optimize process controls.

For Bulletin MSP 161 (Kybernetes Data Processing Systems) and MSP 163 (PowrMag Electronic Control Systems), write to:

HAGAN CHEMICALS & CONTROLS, INC.

DIVISIONS: CALGON COMPANY, HALL LABORATORIES

HAGAN BUILDING, PITTSBURGH 30, PA.

In Canada: Hagan Corporation (Canada) Limited, Toronto

European Division: Via Fiumendosa No. 13, Milano, Italy

EVENTS—CONTINUED

October 28-29
Michigan Industrial Electronics Exposition, Detroit Artillery Armory, Detroit, Mich. For information write W. G. Henschen, 830 W. Vernor Highway, Detroit 1, Mich.

October 28-29
6th Annual Computer Applications Symposium, Morrison Hotel, Chicago, Ill., Armour Research Foundation of the Univ. of Ill., Write M. J. Jans, Conf. Secy., Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

October 29-30
5th Annual Electron Devices Meeting, Shoreham Hotel, Washington, D. C., PGED-IRE, Write J. J. Lanigan, Pub. Chrman, Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.

November 3-5
1959 Mid American Electronics Conference (MAECON) Midwest Research Institute, Kansas City, Mo., Sponsored by KC Section, IRE. Write Paul C. Constant, Jr., Midwest Research Institute, 425 Volker Blvd., Kansas City 10, Mo.

November 4-6
Sectional Meeting of Society for Applied Spectroscopy & Instrument Exhibition. Hotel New Yorker, N.Y.C. For information write M. F. Wilson, Air Reduction Corp. Research Lab., Murray Hill, N. J.

November 4-6
Eastern Analytical Symposium and Instrument Exhibit, New Yorker Hotel, N.Y.C. For information write Paul Lublin, Sylvania Research Laboratories, Bayside, N.Y.

November 5-6
Eighth Annual Instrumentation Conference, on campus of Louisiana Polytechnic Institute. For information write Stewart Baggarly, Louisiana Polytechnic Institute, Ruston, Louisiana.

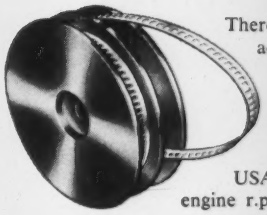
November 10-15
International Exhibition of Laboratory, Measurement and Automation Techniques in Chemistry, Swiss Fair Buildings, Basle, Switzerland. For information write Emil M. Bammater, Swiss Industries Fair, Basle 21, Switzerland.

November 16-19
5th Conference on Magnetism and Magnetic Materials, Sheraton-Cadillac Hotel, Detroit, Mich., Sponsored by Univ. of Mich., IRE, Am. Phys. Soc., ONR, AIEE and Met. Soc of AIME. Write D. M. Grimes, Dept. of E. E., Univ. of Mich., Ann Arbor, Mich.

EXPOSITION POSTPONED

PITTSBURGH—Management for the Fifth International Automation Congress and Exposition has announced postponement of the show scheduled for the New York Trade Show Building, November 16 to 20, 1959. The show will be rescheduled for 1961.

SUCCESSFUL LAUNCH...



There's solid assurance in the high accuracy of Howell Instrument's Ta'Pot®, the "tape-slidewire" potentiometer used as the key measuring unit to check, *before* launch, The Martin Company's USAF TM-76 "Mace" engine r.p.m. and temperature systems—and which is the go/no-go control *during* launch.

The Ta'Pot is a straight wire (or helically wound!), embedded within the edge of a polyester tape. With calibration printed on the tape, this 12-feet long slidewire pot has up to 1200 readout scale points; or it may be geared to an in-line counter, and servo-driven in either case. *Or* the Ta'Pot may be manually operated for exact readout of functions...or for control of functions...or for computer inputs. Electronic calibration of Ta'Pot slidewires regularly achieves better than 0.05% conformity to either linear or non-linear functions. *The Ta'Pot is presently used in test cells, in jet engine analyzers, in jet aircraft cockpits and in a host of other critical applications.*

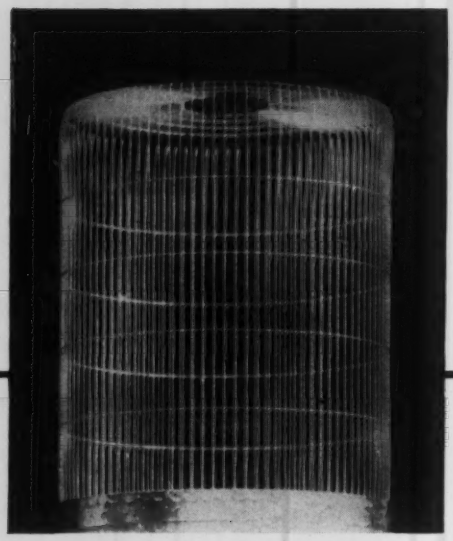
TA'POT®

HOWELL INSTRUMENT COMPANY
3101 Trinity Street, Fort Worth 7, Texas

CIRCLE 34 ON READER-SERVICE CARD

← CIRCLE 33 ON READER-SERVICE CARD

platinum clad tungsten wire is most efficient for high temperature applications



Platinum clad tungsten wire is ideally suited to modern requirements for high power vacuum tube grid and other high temperature applications. Because of its superior physical properties at elevated temperatures, tungsten provides the more rigid, refractory core material required by high power tubes; it also exhibits lower interaction with platinum. Unlike molybdenum, platinum clad tungsten is readily hot-stretched to take a permanent setting and lends itself to fabrication into grids employing conventional fixtures and spot welding procedures. Available in diameters from .001" and up. Write for Technical Bulletin.

BAKER PLATINUM DIVISION • 113 ASTOR STREET
NEWARK, N. J.

BAKER PLATINUM DIVISION

precious metal contacts for high-reliability

For high-reliability and long operating life, precious metal contacts in pure or alloyed forms of silver, platinum, palladium and gold are very definitely indicated. These contacts provide unmatched high resistance to atmospheric corrosion, deformation, arc erosion, binding and metal transfer. Baker precious metal contacts are supplied as wire, rod, sheet and in a complete line of fabricated forms. Facilities are also available for manufacture to your specifications. Write for Baker Contact catalog.

BAKER CONTACT DIVISION • 207 GRANT AVE., E. NEWARK
HARRISON P. O., N. J.

BAKER CONTACT DIVISION

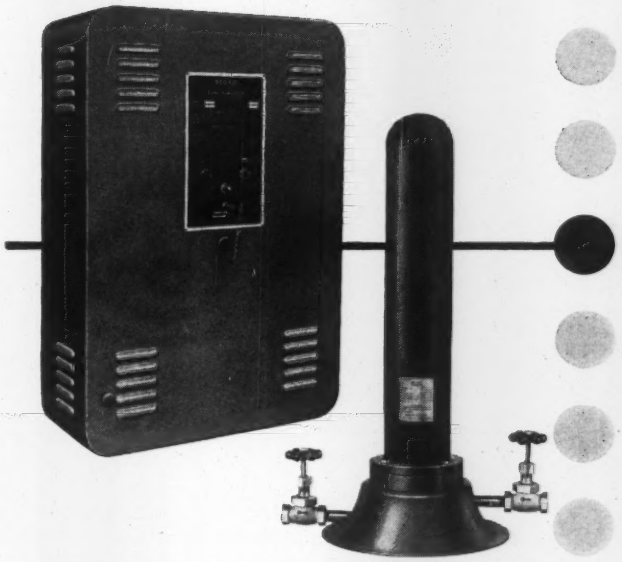
WRITE FOR LITERATURE

DOMESTIC DIVISIONS: AMERICAN PLATINUM & SILVER DIVISION, AMERSIL QUARTZ DIVISION, BAKER CONTACT DIVISION, BAKER DENTAL DIVISION, BAKER SETTING DIVISION, BAKER PLATINUM DIVISION, CHEMICAL DIVISION, EAST NEWARK INDUSTRIAL CENTER, HANOVIA LAMP DIVISION, HANOVIA LIQUID GOLD DIVISION, IRVINGTON-BAKER REFINING DIVISION, D. E. MAKEPEACE DIVISION, NATIONAL ELECTRIC INSTRUMENT DIVISION, RESEARCH AND DEVELOPMENT DIVISION, H. A. WILSON DIVISION. COMPANIES ABROAD: ENGELHARD INDUSTRIES OF CANADA, LTD. TORONTO, ENGELHARD INDUSTRIES OF QUEBEC, LTD. MONTREAL, ENGELHARD INDUSTRIES, LTD. LONDON, ENGELHARD INDUSTRIES A. G. ZURICH, ENGELHARD INDUSTRIES PTY., LTD. MELBOURNE, SOCIEDAD SURAMERICANA DE METALES PRECIOSOS S. A. BOGOTA, INDUSTRIE ENGELHARD S. P. A. ROME, ENGELHARD INDUSTRIES OF SOUTHERN AFRICA, LTD. JOHANNESBURG. ASSOCIATED COMPANIES: ACME TIMBER INDUSTRIES LTD., SOUTH AFRICAN FOREST INVESTMENTS LTD., SOUTH AFRICA, AZOPLATE CORPORATION, CHARLES ENGELHARD, INC., NUCLEAR CORP. OF AMERICA, INC., U.S.A.

CIRCLE 35 ON READER-SERVICE CARD

CIRCLE 36 ON READER-SERVICE CARD

for low cost purification and drying of hydrogen and other gases



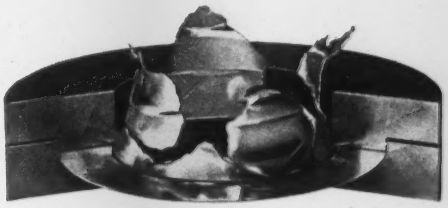
The Deoxo Catalytic Purifier is combined with an extremely efficient automatically operated drying unit to provide oxygen-free hydrogen that is ideally pure and dry. The combined units are identified as the Deoxo Dual Puridryer. It supplies hydrogen with less than one part oxygen per million — dried to a dew point of —100°F. *No inert gas purging is needed.* The Deoxo Dual Puridryer can also be used with other gases such as: Nitrogen, Argon, Helium and saturated hydrocarbons, with equally fine performance. Write for descriptive literature.

CHEMICAL DIVISION • 113 ASTOR STREET
NEWARK, N. J.

CHEMICAL DIVISION

CIRCLE 37 ON READER SERVICE CARD

corrosion-resistant rupture discs for dependable instant and automatic relief of excess pressure



In pressurized apparatus subject to corrosive action, precious metal rupture discs provide the safest, most accurate and dependable relief. Platinum, gold, and silver are now generally recognized as specifics when dealing with corrosion. Each is resistant to the corrosive effects of an important group of liquids and gases and will remain unattacked under conditions that would render many base metal materials useless. These rupture discs, depending on material selected, are guaranteed to be burst ± 5% of specified pressure. Intrinsic value adds to the original cost of these discs but the actual metal value is recovered, no matter how torn or battered the discs may be. Send for Bulletin.

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NEWARK, N. J.

ENGELHARD INDUSTRIES, INC.

EXECUTIVE OFFICES:

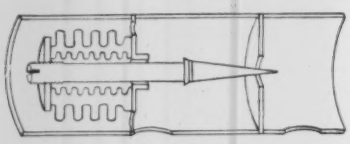
113 ASTOR STREET • NEWARK 2, NEW JERSEY

CIRCLE 38 ON READER-SERVICE CARD

briefs

Compensated Primary Mass Flow Element

The NIL mass flow primary element is a variable orifice in which the area of the orifice is controlled by a bellows assembly sensitive to line pressure and gas temperature. A shaped plug attached to the bellows assembly extends into the orifice. The bellows assembly contains a gas permanently sealed in. An increase in

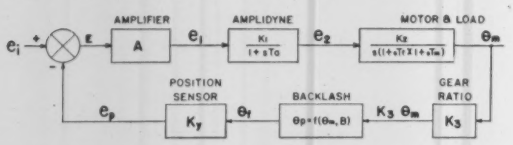


line pressure compresses the bellows so that the pressure inside the bellows is essentially the same as line pressure . . . The shaping of the plug is such that the effective area of the annular orifice produced is inversely proportional to the square root of P/T. This is exactly the compensation required to make the square root of the differential pressure proportional to the mass flow rate (independent of pressure and temperature) . . . (*From new 4-page Bulletin 178, National Instrument Laboratories, Inc., 823 Evarts St., N. E., Washington, D. C.*

FOR THIS LITERATURE CIRCLE 165 ON READER-SERVICE CARD

How to Simulate a Non-Linear Control System with an Analog Computer

Several mathematical techniques have been developed for rapid, accurate analysis and design of linear feedback systems. When the designer faces non-linearities which significantly influence system performance, such techniques are awkward and time con-

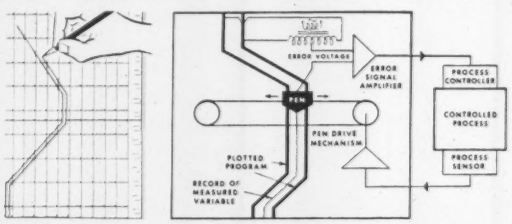


suming . . . Simulation is by far the easiest and certainly the most accurate solution. Simulation lets the designer examine system performance under the influence of varied parameters . . . A computer wiring diagram . . . (shows how) this circuit uses standard computer amplifiers with transfer functions equal to those shown in the functional diagram of the system (Figure 2) . . . (*From new Donner Tech Notes, No. 1, Donner Scientific Co., 888 Galindo St., Concord, Calif.*)

FOR THIS LITERATURE CIRCLE 166 ON READER-SERVICE CARD

New Automation Programmer, Guided by Pencilled Graph, Records Process Performance on Same Chart

At first glance the new instrument (trade name Prekorder) looks much like conventional circular and strip-chart recorders . . . The program appears as a double-line graph, pencilled directly on the recording chart (Figure). The controller, sensing any deviation of the recording pen from the middle of the pencilled graph regulates the process to oppose the deviation

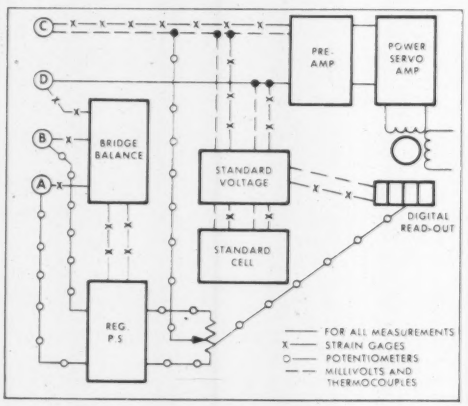


. . . The two parallel pencil lines that define the process program are connected electrically to the two ends of a centertapped transformer winding which serves as a voltage source for an electrostatic field between the lines (Figure). The recording pen, serving also as a capacitive probe, picks up an error signal proportional to any deviation of the pen from its null position midway between the program lines . . . The Prekorder system of programming-controlling-indicating-recording is usable wherever conventional chart recorders are used, as it is adaptable to any process which may be electrically controlled and which can be monitored by a transducer either mechanically or electrically connected to the recording pen . . . (*From new 3-page description; Research, Inc., 115 N. Buchanan St., Hopkins, Minn.*)

FOR THIS LITERATURE CIRCLE 167 ON READER-SERVICE CARD

Ratio Digital Millivoltmeter

Measures: potentiometers, thermocouples, strain gages (bonded and unbonded), low level dc voltages.



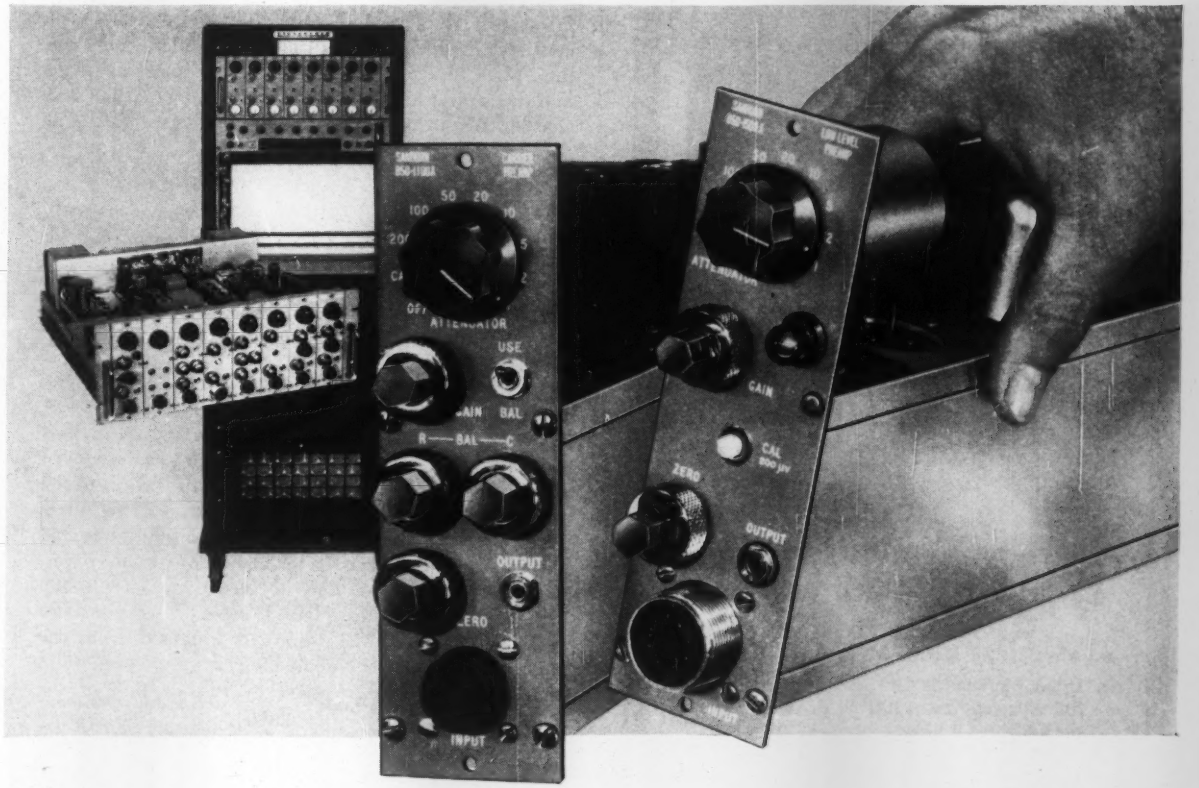
Reads 1MV full scale to 0.1% accuracy . . . (*From new 2-page pamphlet, Technical Industries Corp., 389 North Fair Oaks, Pasadena, Calif.*)

FOR THIS LITERATURE CIRCLE 168 ON READER-SERVICE CARD

NEW

CARRIER AND LOW LEVEL PREAMPS OFFER MORE RECORDING USEFULNESS

–per inch
–per dollar
–per channel



WITH the availability of these two new plug-in preamplifiers and associated MOPA, Sanborn 6- and 8-channel "850" oscillographic recording systems can now record an even *wider* variety of inputs — wherever *many channels* are needed in *minimum panel space*, with *no* sacrifice in system accuracy or reliability. The 850-1100A is a carrier amplifier-demodulator unit designed to work with resistance bridge, variable reluctance and differential transformer transducers. Attenuator, smooth gain, position and balancing controls are on the 2″ x 7″ front panel; input and output connections are provided at both front and rear. The 850-1500A is a chopper amplifier with floating input isolated from a floating output, capable of measuring low level DC-100 cps signals such as those from thermocouples and strain gage bridges. Design provides low noise operation, greater freedom from ground loop interference and high common mode rejection ratio. Required carrier excitation (2400 cps standard, 600, 1200 and 4800 cps optional) and chopper drive (440 cps) voltages are supplied by the 850-1900 MOPA, a dual-oscillator unit which can handle up to eight of each preamplifier.

SPECIFICATIONS

	850–1100A	850–1500A
Sensitivity	100 μv in gives 1 v at outp	
Input impedance	approx. 2500 ohms	approx. 100,000 ohms
Output	±2.5v across 3300 ohms	±2.5 volts across 2500 ohms
Freq. response	−3 db at 20% of carrier freq.	0–100 cps, −3db
Linearity	±0.5% of full scale	±0.1% of full scale
Common mode performance		120 db for 60 cps, 160 db for DC with 5000 ohms unbalance in input
Noise		2 μv p-p over 100 cps bandwidth

(data subject to change without notice)

Ask your Sanborn Sales-Engineering representative for complete facts on all "850" system units — or write the main office in Waltham.

SANBORN COMPANY
Industrial Division
175 Wyman St., Waltham 54, Mass.

CIRCLE 39 ON READER-SERVICE CARD

ANNOUNCING

Model 520 . . . manual range switching AC, DC, OHMS . . . $1190. Rack or portable.

Model 500 . . . automatic range switching DC only . . . $1190. Rack or portable.

The First New Development in Digital Voltmeters

- Absolute dc accuracy . . . 0.1% full scale.
- *Input impedance (dc) . . . approaching infinity except on 1200 V dc which is 20 megohms.
- Requires no lead switching . . . polarity indication is automatic.
- Requires no range switching on Model 500 . . . range is switched automatically.
- High stability, all-electronic four-digit indication appears in less than 125 milliseconds after step function voltage is applied across test leads.
- 0.001 to 1200 V dc range. Model 520 also reads 0.001 to 1200 V ac and 1 ohm to 1 meg.
- Output provisions for direct drive of printer or tape punch.
- Rack mounting or portable.
- Guaranteed long term stability at least 24 hrs. after 10-minute warmup and internal calibration.

* May be quickly zeroed for effectively infinite input impedance.

FRANKLIN electronics, inc.

BRIDGEPORT • PENNA.

CIRCLE 40 ON READER-SERVICE CARD

BRIEFS—CONTINUED

Integrator for all Orifice-Meter Charts

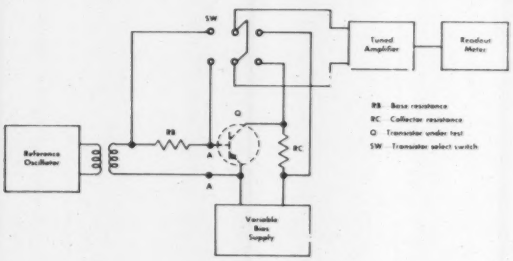
The Rockwell Integrator (Series 1000) uses the . . . square root cam principle . . . The heart of this principle rests in the Integrator's top mechanism which consists of three discs or plates, the smallest being the time plate, the intermediate being the pressure plate and the largest being the chart plate . . . The time and chart plates are geared together in constant rate and

driven by a variable speed A.C. or D.C. motor. The pressure plate is positioned above the time plate. Between these plates contacting them is a steel disc roller, called the pressure roller, which can be moved across the face of the time plate from the center to the right outer edge. By moving the position of the pressure roller, the speed ratio between the time plate and the pressure plate can be changed. A second roller, the differential roller, can be moved across the top surface of the pressure plate. Connected to this roller is a dial counter. The resultants obtained from the counter are dependent upon the frictional speed ratio changes which are governed by the position of the rollers moving across the plates . . . (*From new* 8-*page Bulletin* 1016, *Rev.* 8, *Rockwell Mfg. Co.*, 400 *N. Lexington Ave., Pittsburgh* 8, *Pa.*)

FOR THIS LITERATURE CIRCLE 169 ON READER-SERVICE CARD

Transistor Tester

The Sierra Model 219A Transistor Tester represents a genuine technical breakthrough in permitting in-circuit Beta testing of transistors without removing them from the circuit. The instrument is also capable of measuring the collector current parameter, as well as Beta, with the transistor removed from the circuit . . . Basically the Model 219A consists of a fixed fre-



quency oscillator with special circuitry designed to overcome the large measurement errors which would otherwise result from loading by external circuits.

Low impedance methods in both the input and output circuits of the tester are utilized among other special techniques, to negate the effects of surrounding circuitry. The signal generated is coupled to the transistor under test and is used as the reference source. The impedance across the base-emitter of the transistor causes it to be biased essentially for Class B operation and the transistor will therefore conduct only when the input level signal exceeds the work function of the emitter-base diode.—(*From new 2-page Bulletin* 124, *Sierra Electronic Corp.*, 3885 *Bohannon Drive, Menlo Park, Calif.*)

FOR THIS LITERATURE CIRCLE 170 ON READER-SERVICE CARD

Test Instrument Procurement

Studies show that most companies waste up to 20% of their annual expenditures for test equipment. The principal cause lies in the inability of each company to make the best possible buy. Purchases are made with incomplete knowledge of the full range of available instruments . . . Technical Information Service

52 D. C. POWER SUPPLIES

LABORATORY TYPE 0-300 Volts 300 ma - 1.5A.

Manufacturer	Model	Output Voltage Min.	Output Voltage Max.	Cur. Ma.	% Regulation Line	% Regulation Load	% Regulation Total	Ripple mv.
		1	2	3	4	5	6	7
DRESSEN-BARNES	D3-300E	a 0 b 0	300 300	300 150	.075	.100 av.	1ma	.2 rms
DRESSEN-BARNES	D3-300D	a 0 b 0	300 300	300 150	0.15	.60 av.	1ma	1
ELECTRONIC MEASUREMENTS COMPANY	233-A	0 *	300	300	0.1	0.1	1ma	

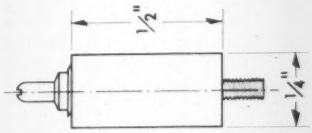
(TIS) provides you with complete, timely by product information about all electronic test equipment. In minutes you possess detailed descriptions of equipment produced by every manufacturer . . . Descriptions include full specifications, prices, and the names and addresses of local sales representatives—all the information you need to initiate procurement.—(*From new* 8-*page Bulletin* 744, *Technical Information Corp.*, 41 *Union Square, Room* 1001, *New York* 3, *N. Y.*)

FOR THIS LITERATURE CIRCLE 171 ON READER-SERVICE CARD

Transistor-Size Pressure Switch

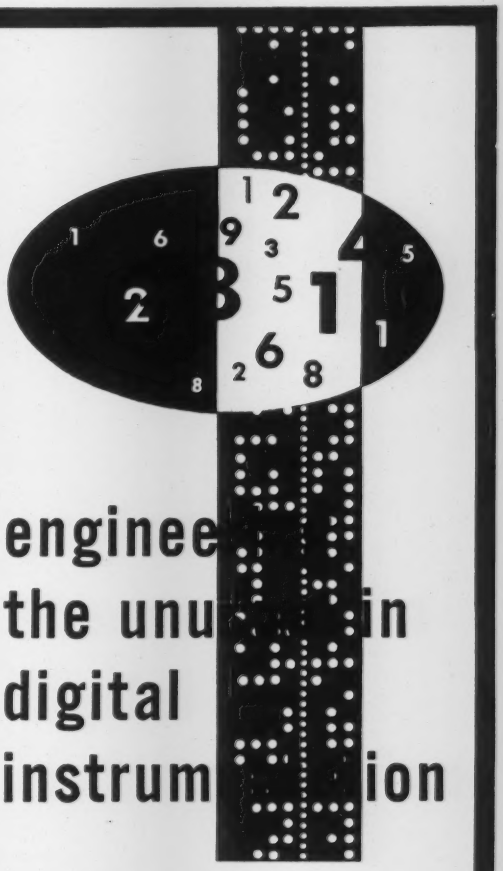
This transistor size pressure switch for surge, leak, and variance detection in all types of systems is now in use as automatic lead detector on missile programs.

Pressures—Setting Limits: 1 to 100 psig. Operating Range: 1 to 500 psig. Proof Pressure: 3000 psig. Burst Pressure: 5000 psig.



Electrical Rating—Contact Resistance: Less than 0.1 ohm @ 5 milliamperes. 0.1 amp. inductive at 28 V d-c. 0.2 amp. resistive at 28 V d-c. Insulation Resistance: Greater than 5 megohms @ 325 VAC RMS. Contact Arrangements: SPST . . . (*From new* 2-*page Pamphlet "Transistor Size Pressure Switch," Century Electronics and Instruments, Inc.*, 1333 *N. Utica, P. O. Box* 6216, *Tulsa* 10, *Okla.*)

FOR THIS LITERATURE CIRCLE 172 ON READER-SERVICE CARD



Peak engineering loads, tight delivery schedules, shortages of personnel . . . all place an added strain on overtaxed engineering facilities. If digital equipment engineering is part of this load, Franklin Electronics' Communications and Control Division can serve you best. Franklin's C & C Division, working in close cooperation with your engineering staff, designs and develops digital instruments and data systems to your specifications.

Whether the need is for a complete data acquisition and reduction system, a language translator, or a simple digitizer, you'll be pleased with how the C & C Division can ease your engineering load. But most of all, you'll be pleased with the final product . . . delivered on time . . . on a guaranteed performance basis.

Bulletin CC-220 describes the work of the C & C Division, its facilities, some of the equipment it has developed in the past . . . and how it can assist you now. Write for a copy. There's no obligation, of course.

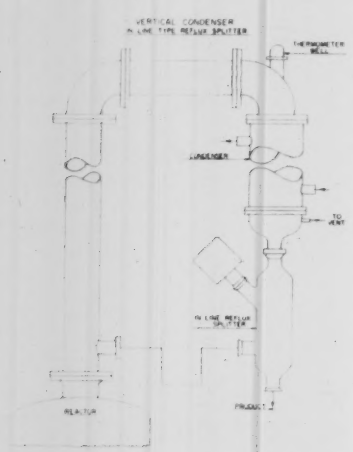
FRANKLIN electronics, inc.

COMMUNICATIONS AND CONTROL DIVISION
VAN NUYS, CALIFORNIA

CIRCLE 41 ON READER-SERVICE CARD

Automatic Reflux Splitter

The splitter is electrically operated by use of a solenoid and timer for dependable accurate performance. The elimination of valves, product line and reflux line rotameters makes the use of the Reflux Splitter an economical component of your process pipe layout. A precision timer with an adjustable ratio of 1:1 to



1:120 will operate constantly to assure you of uniform product control. These timers are available in general purpose or Class 1, Group D explosion proof enclosures . . . The in-column design . . . (has a) . . . Teflon gate (as) the only moving part. This simplicity offers the rugged trouble-free construction essential for process equipment. In operation the timer energizes the solenoid whose glass enclosed core pulls up the teflon gate so that the reflux line is open.—(*From new 4-page Bulletin RS-2, Chem Flow Corp., 119 Dell Glen Ave., Lodi, N. J.*)

FOR THIS LITERATURE CIRCLE 162 ON READER-SERVICE CARD

Ultra-Sensitive Volt-Ammeter

The Keithley 150 Micro Volt-ammeter offers a twenty-fold improvement in sensitivity, stability, and noise figure compared with other micro-voltmeters. It may also be used as an amplifier, null detector, micro-microammeter, and (with an external voltage supply) meg-megohmmeter. Functions and measurement spans include:

Dc Voltmeter, 1 microvolt to 1 volt full scale; Ammeter, 10^{-10} to 10^{-3} ampere full scale; DC Amplifier, gains of 10 to 10,000,000 Null Detector, with 0.5 to 2 second period.

Other features of the 150 include zero suppression of up to 100 times full scale: optional floating or grounded input; high input resistance; zero stability as a voltmeter with $\pm 2 \times 10^{-11}$ ampere per day as an ammeter; short term noise within 0.03 microvolt peak to peak (0.006 microvolt RMS.) . . .

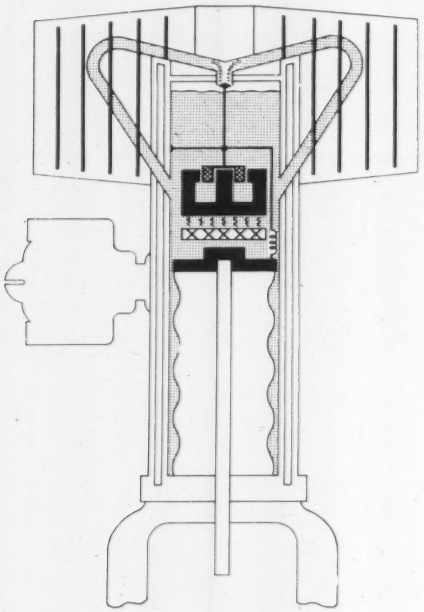
Input Resistance is the resistance of the primary of the chopper transformer increased by the application of overall negative feedback. The effective input resistance is one megohm on the one-microvolt range, 3 megohms on the three-microvolt range, increasing to a maximum of 90 megohms on the 100-microvolt range . . .

Zero Stability: After a one hour warm-up within ± 0.1 microvolt $\pm 2 \times 10^{-5}$ R microvolts per day, where R is the source resistance in ohms.—(*From new 4-page "Keithley Engineering Notes," Vol. 7/No. 1, Keithley Instruments, Inc., 12415 Euclid Ave., Cleveland 6, Ohio*).

FOR THIS LITERATURE CIRCLE 163 ON READER-SERVICE CARD

Thermo-Drive Valve Actuator

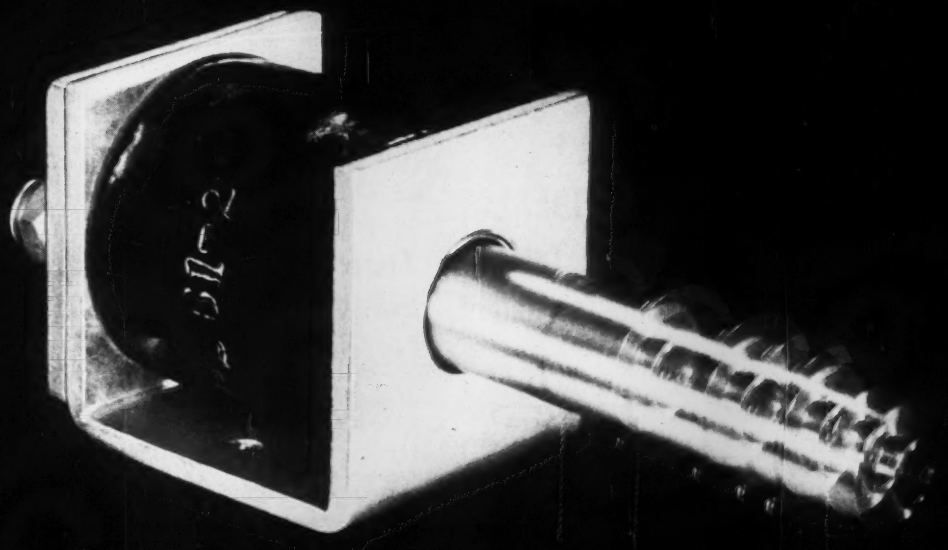
Thermo-Drive Actuators operate on the basis of the controlled rate of heat release through the medium of a fluorinated hydrocarbon compound (Freon). All internal parts of the actuator are submerged in the Freon compound, which is subject to a constant (noncritical) heat input. The heat causes constant vaporization of the compound, thus tending to increase



pressure within the system. The operating coil, coupled with the feedback arrangement, controls a heat-release valve which regulates the release of vapor through a cooling condenser and, then back into the system. While rate of heat input is more or less constant, rate of heat release is controlled. When the rate of heat release is reduced, pressure builds up within the actuator, causing the bellows to contract and actuating the valve in a down-stroke. When rate of heat release is increased, the bellows expands causing upstroke . . . (*From new 4-page Bulletin A-900, Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio*)

FOR THIS LITERATURE CIRCLE 164 ON READER-SERVICE CARD

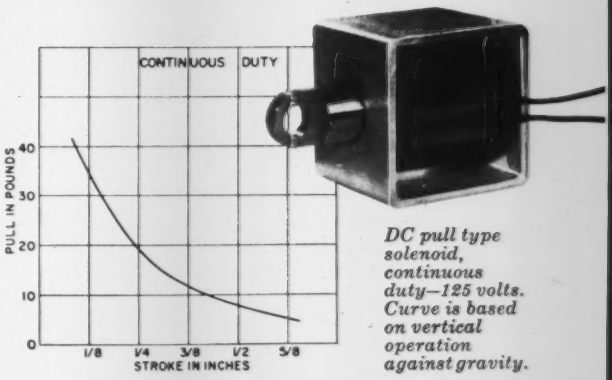
100 MILLION OPERATIONS!



new ASCO solenoid has virtually unlimited life!

This is ASCO's new long-life solenoid. Unlike ordinary solenoids where plunger rides loosely in the sleeve this device is precision manufactured to tolerances of ± .0005". A rugged machine tool bearing guides plunger to provide accurate, smooth stroking. There is virtually no wear—almost unlimited solenoid life.

If your application calls for a precision solenoid that must operate consistently and indefinitely, investigate this new long-life ASCO design. ASCO solenoids are available to meet a wide variety of applications. For additional information contact your ASCO engineer or write for Catalog 57-S5.



DC pull type solenoid, continuous duty—125 volts. Curve is based on vertical operation against gravity.

Automatic Switch Co.

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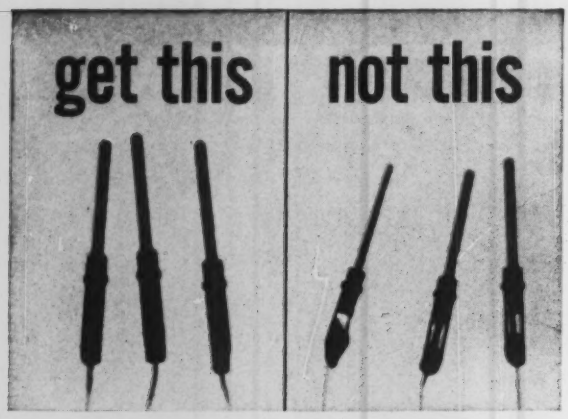
AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

ASCO®

CIRCLE 43 ON READER-SERVICE CARD



Actual X-ray Photos Show How IDEAL Thermo-Tip Resistance Soldering Tools Reduce Costly Voids in Winchester and Cannon Plug Pins

Because the whole pin is heated, "cold-flow joints" are eliminated; failures are greatly reduced

Pin No.	Conduction Method		Resistance Method	
	Length of void	% of void	Length of void	% of void
1	0.12″	40	0.00″	0
2	0.12″	40	0.00″	0
3	0.07″	23	0.05″	17
4	0.18″	60	0.00″	0
5	0.06″	20	0.06″	20
6	0.05″	17	0.04″	13
7	0.02″	7	0.05″	17
8	0.08″	27	0.01″	3
9	0.09″	30	0.07″	23
10	0.12″	40	0.09″	30
11	0.15″	50	0.04″	13
12	0.12″	40	0.06″	20
13	0.09″	30	0.01″	3
14	0.12″	40	0.08″	27
15	0.11″	37	0.02″	7
16	0.10″	33	0.04″	13
17	0.07″	23	0.04″	13
18	0.09″	30	0.09″	30
19	0.11″	37	0.10″	33
20	0.11″	37	0.06″	20
21	0.05″	17	0.01″	3
22	0.15″	50	0.00″	0
23	0.11″	37	0.05″	17
24			0.07″	23

● These production test results from a major Aircraft manufacturer prove the superiority of Ideal Resistance Soldering Tools to the best available commercial soldering irons. Voids averaged 33% with soldering irons. With resistance soldering only 14%.

In addition, higher production speeds were possible on Cannon plugs and operators were less subject to painful burns. Send for descriptive literature.

IDEAL INDUSTRIES, Inc. 1420-1 Park Ave., Sycamore, Ill.

Gentlemen: Please send complete catalog information about Ideal's Thermo-Tip Resistance Soldering Tools.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

CIRCLE 44 ON READER-SERVICE CARD

Your Career with the Instrument and Control Industry

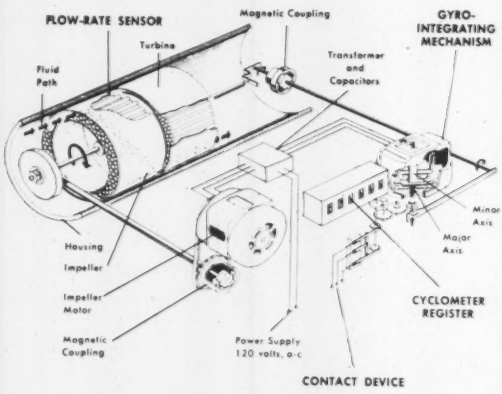
What is the Instrument and Control Industry? . . . What are Instruments and Controls? . . . Where are Instruments and Controls Used? . . . What Kinds of Engineering are available in the Instrument and Control Industry? . . . What is the Opportunity for the Future? . . . (*From new 6-page pocket-size bulletin, Recorder-Controller Section of Scientific Apparatus Makers Assoc., 370 Lexington Ave., New York 17, N. Y.—A bulletin every reader should have!*)

FOR THIS LITERATURE CIRCLE 173 ON READER-SERVICE CARD

True Mass Flowmeter Unaffected by Supply Fluctuations

Completely self-contained, the Type LB mass flowmeter includes four basic components: (1) flowrate sensor; (2) gyro-integrating mechanism; (3) cyclometer register; and (4) contact device.

(1) Flow-rate sensor . . . consists of two cylindrical elements—the impeller and the turbine. Both elements

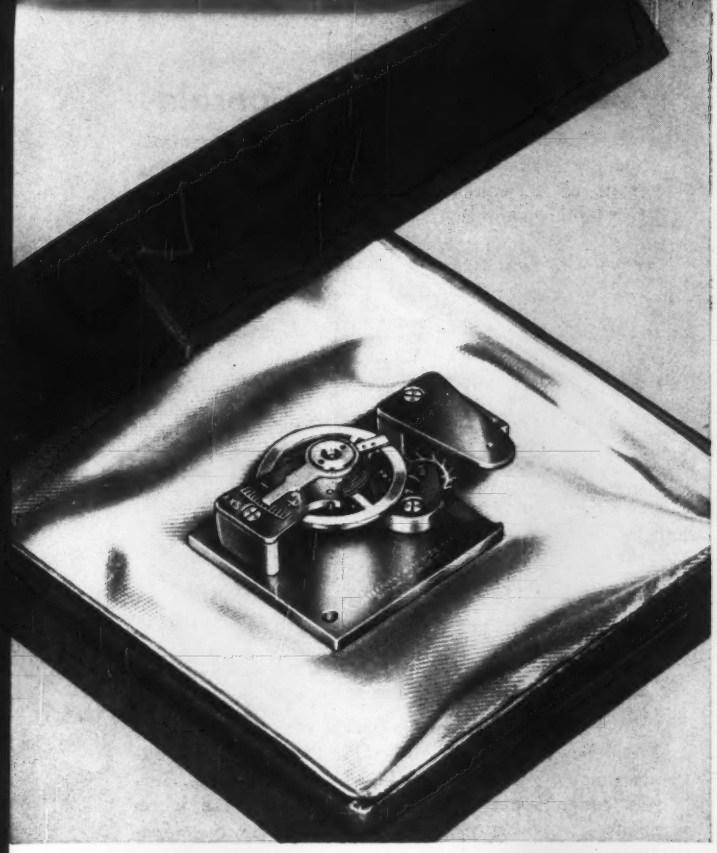


contain channels through which the fluid flows. The impeller is driven at a constant speed by a synchronous motor (through a magnetic coupling) and imparts an angular velocity to the fluid as it flows through the meter. The value of this angular momentum added to the fluid is proportional to the mass rate of flow.

The second cylinder removes all angular momentum from the fluid and in doing so receives a torque proportional to the angular momentum. The torque, proportional to the mass rate of fluid flow, is independent of fluctuations in fluid density.

(2) Gyro-integrating mechanism receives this torque through a magnetic coupling and it is applied around the minor-axis of the gyroscope. This causes the gyro to rotate its major axis at a rate proportional to the torque (and thus to the mass rate of fluid flow) . . . (*From new 8-page Bulletin GEA-6925, General Electric Co., Instrument Dept., West Lynn, Mass.*)

FOR THIS LITERATURE CIRCLE 174 ON READER-SERVICE CARD



Now there's a New "Jeweled" Escapement in ROCKWELL CHART DRIVES

for greater accuracy and longer life

This jeweled movement brings fine watch quality to instrument timing

SPEED CHANGING TURRETS PROVIDE SEVEN DIFFERENT ROTATION RATES

The basic Rockwell Chart Drive has a main arbor rotation rate of 7 days. Economical snap-on turrets permit changing to 8-day, 15-day, 16-day, 24-day, 30-day, 31-day, and 24-hour rotation. No tools or special skills are required. You can even change chart rotation without removing the drive from the instrument.

The introduction of a jeweled movement—the first ever used on a general industrial timing device made in the United States—makes the Rockwell more accurate than any unjeweled chart drive could possibly be. In addition to offering fine watch quality, the jeweled escapement requires less power to operate and is extremely durable, since seven hard jewel surfaces are provided to limit friction and wear.

You will benefit in many ways by using these jeweled movement chart drives for powering all your recording instruments. They adapt readily to fit into practically any instrument case while speed-changing turrets (see left) permit changing rotation rates at will. Write for full information. Rockwell Manufacturing Company, Instrument Division, Pittsburgh 8, Pa.

JEWELED CHART DRIVES

another fine product by

ROCKWELL

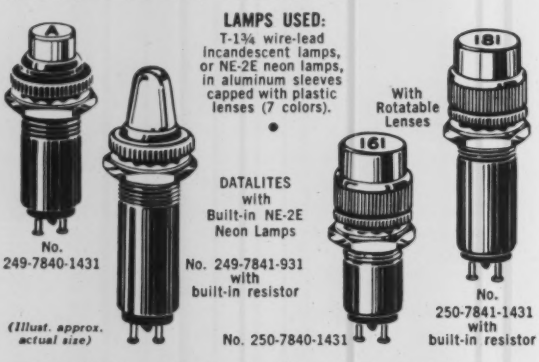
CIRCLE 58 ON READER-SERVICE CARD

In this brochure—complete facts on DIALCO's

DATALITES®

For the Computer-Automation Industries

DATALITES by DIALCO are ultra-miniature Indicator Lights specially designed to meet the critical requirements of the computer-automation fields. Made in 2 basic styles: *Lamp Holders with* DIALCO'S own *replaceable Lamp Cartridges* (see above); or integrated DATALITES *with Built-in Neon Lamps* which are *not replaceable* (see below). Ultra-compact, single units mount in ⅜" clearance hole; the twin-lamp assembly mounts in ¾" clearance hole.


LAMPS USED:
T-1¾ wire-lead incandescent lamps, or NE-2E neon lamps, in aluminum sleeves capped with plastic lenses (7 colors).
With Rotatable Lenses
DATALITES with Built-in NE-2E Neon Lamps
No. 249-7840-1431
No. 249-7841-931 with built-in resistor
No. 250-7840-1431
No. 250-7841-1431 with built-in resistor
(Illust. approx. actual size)

DATALITES have fully insulated terminals and conform to all applicable military specifications. Integrated units are available *with or without built-in resistors.* The cylindrical lenses can be hot-stamped with digits, letters, etc. Complete details in *Brochure L-160.* Send for it now.

SAMPLES ON REQUEST—AT ONCE—NO CHARGE

Foremost Manufacturer of Pilot Lights

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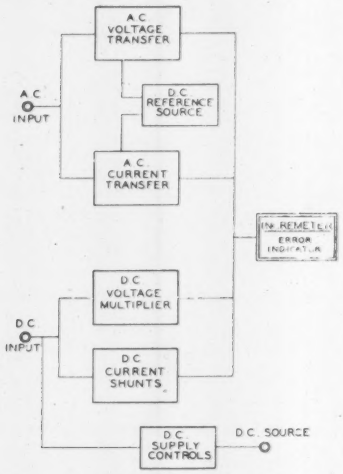
CIRCLE 46 ON READER-SERVICE CARD

Standardizing Test Console

The AC portion of the standardizing test console utilizes a thermocouple as the transfer device for comparison of AC voltages or currents to a very precise DC reference source.

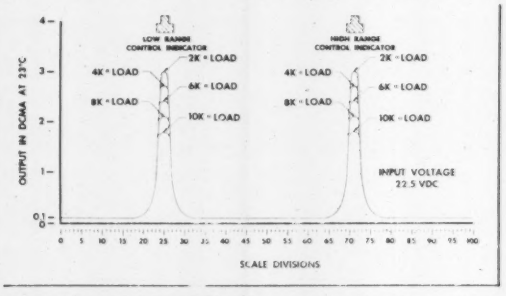


Accuracy on all ranges is 0.05% of actual readings. Frequency range is DC and AC to 25,000 cycles. Voltage range 0.5 v to 1111.5 v in 0-1-volt increments. Current range 1 ma to 11.115 amperes in 1 ma increments . . . (*From new 4-page Preliminary Specifications for Model LTC, Sensitive Research Instrument Corp., New Rochelle, N. Y.*)

FOR THIS LITERATURE CIRCLE 175 ON READER-SERVICE CARD

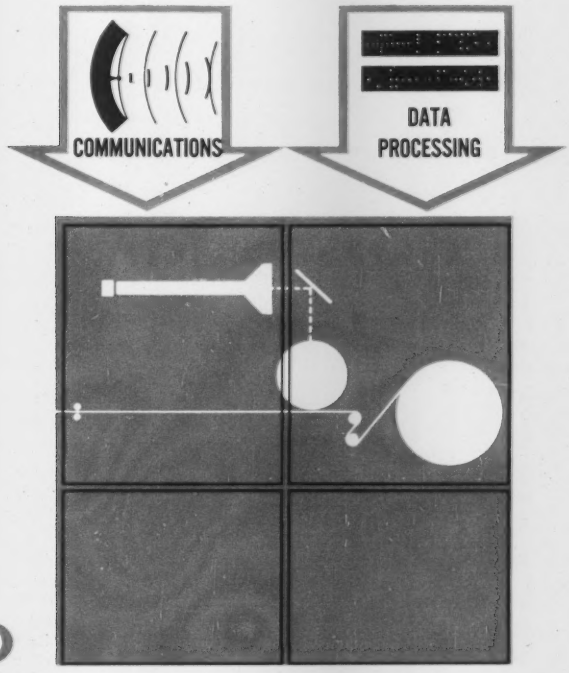
Miniature Controller

Operation—The Model 2545 Meter employs a rugged D'Arsonval type movement. A metal shield attached to the pointer is so positioned that it can pass between two mutally coupled coils of the integral transistorized circuit. This decreases the pick-up signal and switches the output stage from a low-conducting to a high-conducting state. This change in output is sufficient to operate most sensitive relays. Duration of the high-conducting state depends on the length of time the shield remains between the coils. The signal is generated on both up-scale and down-scale travel of the pointer. . . (*From new 4-page Bulletin "Model 2545", International Instrument, Inc., P. O. Box 2954, New Haven 15, Conn.*)



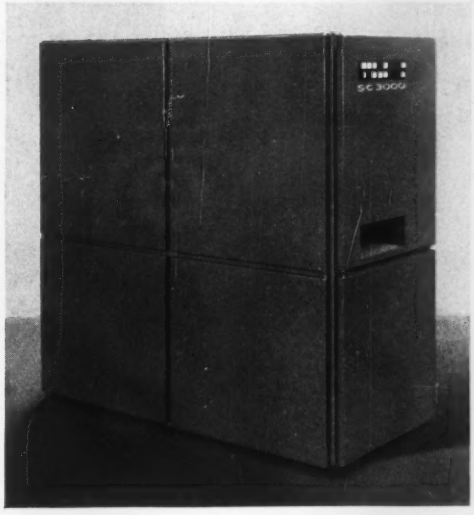
OUTPUT vs. SCALE DIVISIONS . . . indicating the controlling area relative to the entire scale.

FOR THIS LITERATURE CIRCLE 176 ON READER-SERVICE CARD



S-C 3000

MOST VERSATILE OF MEDIUM-SPEED ELECTRONIC PRINTERS



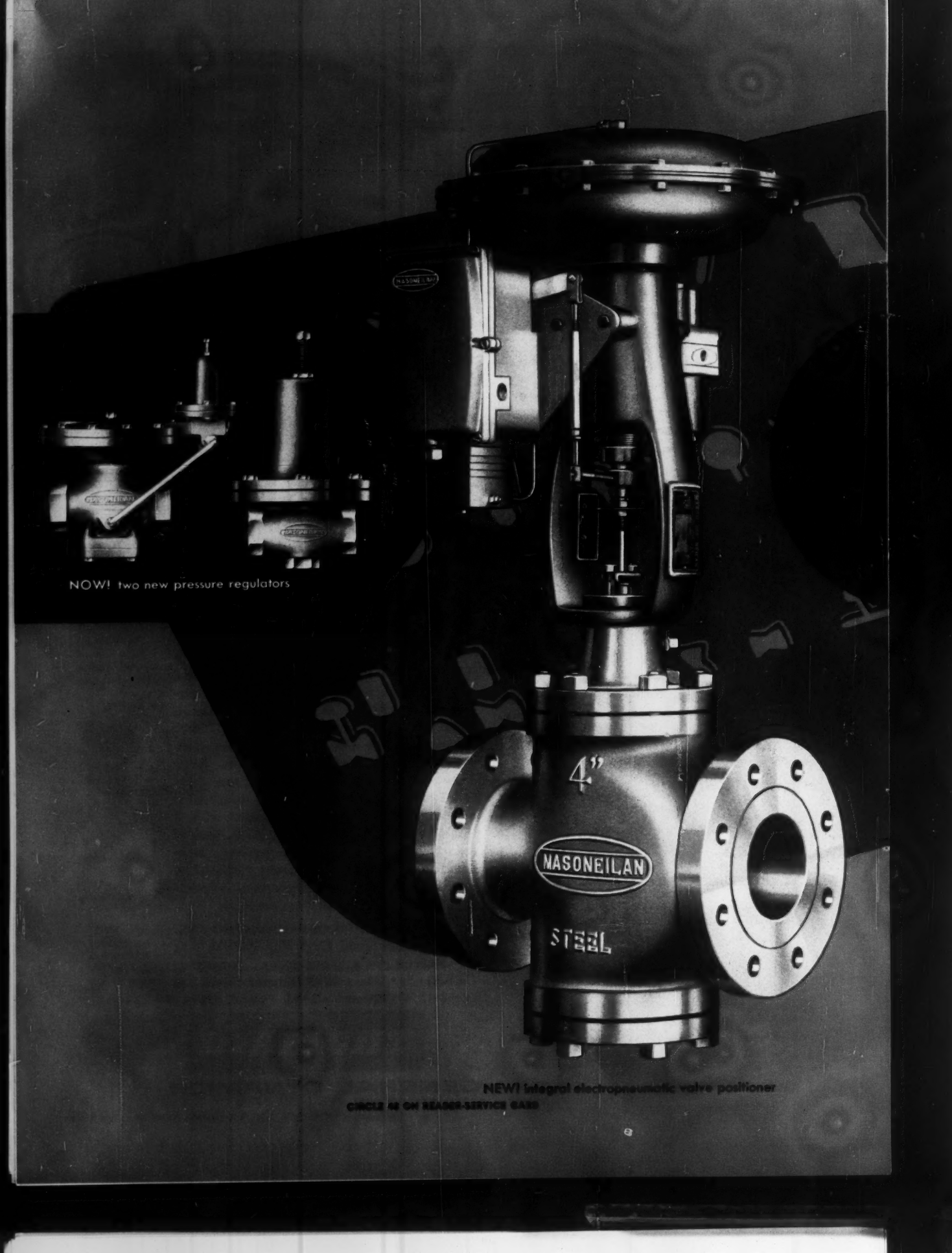
Printing ten to *10,000* words (500 lines) per minute, the S-C 3000 Medium-Speed Electronic Printer meets the demanding requirements of high-speed communications networks and data processing systems for reliable, economical printout equipment. The versatile S-C 3000 is compatible with most computers now in use and with such binary data links as telephone, telegraph and microwave. In addition to dry printing alphanumeric and symbolic data, the S-C 3000 is capable of facsimile reproduction. By combining the CHARACTRON® Shaped Beam Tube and the xerographic printing process, the S-C 3000 prints electronically on inexpensive, untreated paper — *without* impact, *without* troublesome, high-speed moving parts, *without* use of liquid developer — surpassing "high-speed" electromechanical printers in reliability, economy and simplicity of operation, yet printing at comparable speeds.

Send for complete information concerning S-C 3000 Medium-Speed Electronic Printers. Ask for Bulletin 9-C. Write today: Stromberg-Carlson - San Diego, 1895 Hancock Street, San Diego 12, California.

STROMBERG-CARLSON

A DIVISION OF **GENERAL DYNAMICS**

CIRCLE 47 ON READER-SERVICE CARD



NOW! two new pressure regulators

NEW! integral electropneumatic valve positioner

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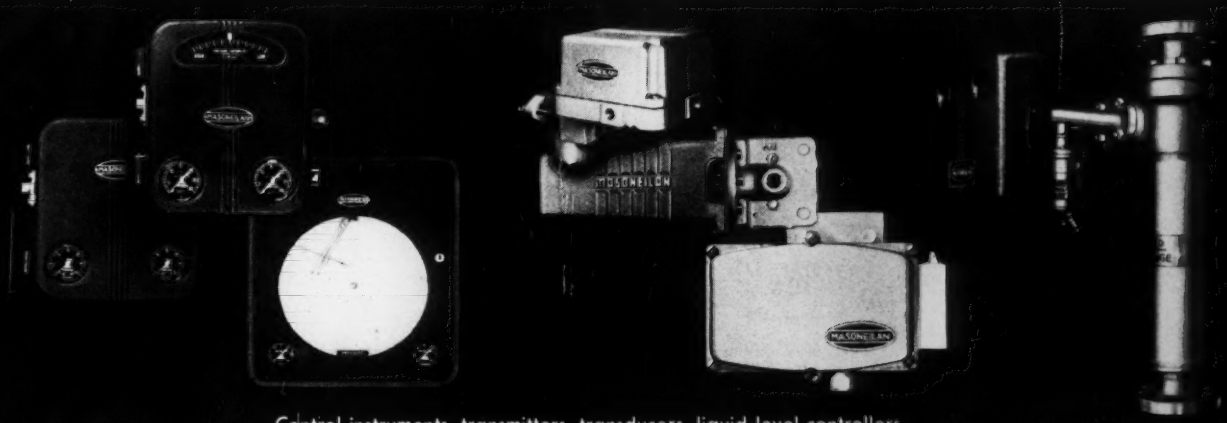
Standard Versatility... Modern Approach to Cost-Saving Control

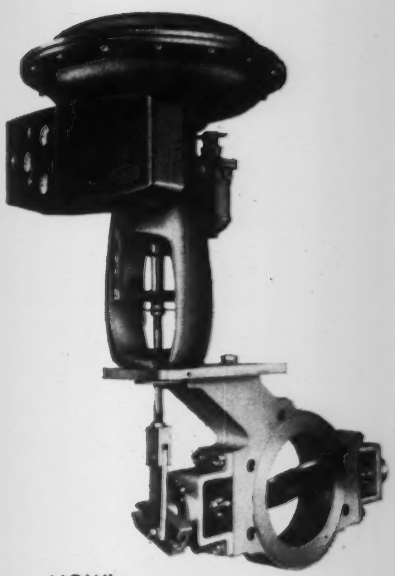


Control instruments, transmitters, transducers, liquid level controllers

The designed-in versatility of major Masoneilan product lines permits a selection of *standard* control equipment for all usual installations and many of the tougher applications.

- **Control Valves:** an exceptionally wide variety of body styles and trim types (many of them interchangeable) enables you to obtain the best combination for your particular service.
- **Indicating, Recording and/or Controlling Instruments:** built from unit subassemblies; permits the selection of desired components for the pneumatic control action or function desired.
- **Transmitters:** interchangeable primary elements simplify the transmission of pressure or temperature, flow or level measurement.
- **Positioners:** pneumatic or electropneumatic positioners and/or electropneumatic transducers offer a choice for either pneumatic or electric control systems.
- **Butterfly Valves:** the versatile butterfly valve line permits multiple variations by simple rearrangements of linkage; choice of actuator types, liners, seating or nonseating designs and mounting styles.

This "standard" versatility of Masoneilan products results in lower maintenance costs and reduced delivery delays. It will pay you to learn how this versatility can be adapted to *your* advantage. Call a Mason-Neilan representative or write for catalog.



NOW!
new developments in Masoneilan Butterfly Valves — soft seats, angle seating, body liners, actuators

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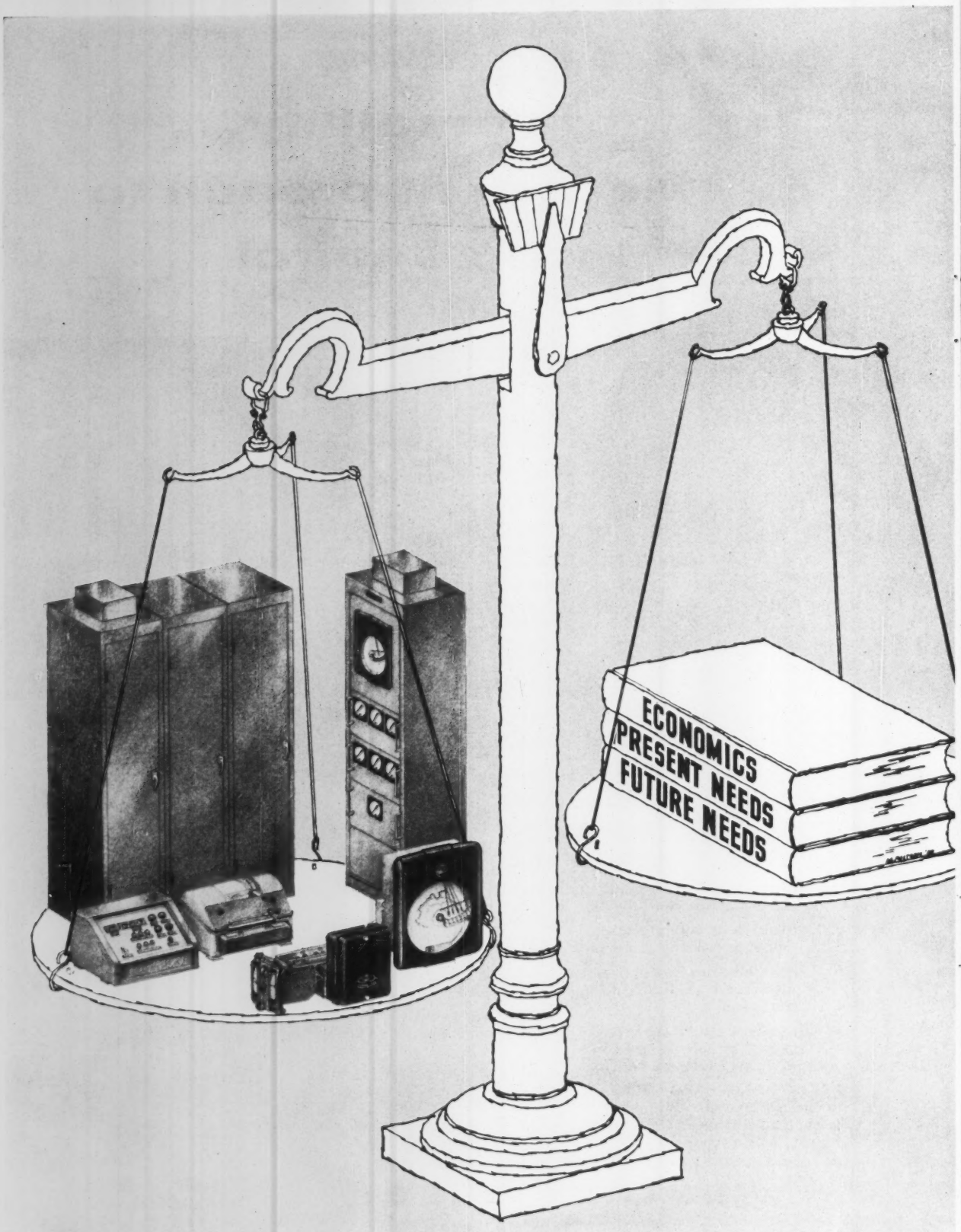
MN 9-22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PRESENT NEEDS
FUTURE NEEDS

BAILEY

BALANCES ALL THESE FACTORS TO HELP YOU REACH OPTIMUM PERFORMANCE

Bailey takes a sensible systems approach by analyzing the immediate and future needs as well as the control economics of your complete process.

Backed by 40 years' experience in the field of measurement and control, Bailey engineers can insure that your system will have the proper balance both as to economics and needs . . . that there will not be the unnecessary expense of over-instrumentation or control . . . nor the duplication of equipment functions.

To effect this approach, Bailey offers a complete line of process and power system components:

Equipment—Primary sensing devices, indicators, recorders, loggers, control units, panels, data-handling equipment and computers for performance analysis, and supervisory controls.

State-of-the-Art—Conventional and sophisticated designs ranging from mechanical, pneumatic and electric thru electronic and solid-state.

Because all of these components are *standardized and compatible*, you have building block flexibility. You can add to your system as the need arises for more control or analysis.

Our complete line gives you one-source buying . . . one responsibility . . . qualified systems engineering . . . fast service . . . experienced field assistance on one instrument or on a complete system. Call our nearest office or write for information today.

G150-2

Instruments and controls for power and process

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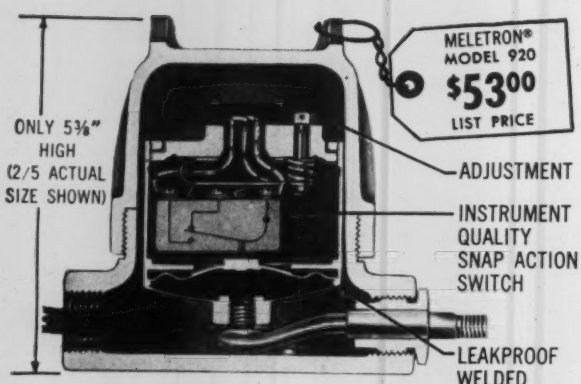


Here's the Simplest Diaphragm Pressure Switch for Explosive Atmospheres

WE BUILD IN	WE DON'T USE
EXTREME ACCURACY and DEPENDABILITY maintained during operating life due to direct acting design	LINKAGES & BEARINGS which, as they wear, make the setting of the pressure switch drift.
OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch that uses liquid switching elements	LIQUID SWITCHING ELEMENTS which make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	ACCORDION BELLOWS which make the pressure switch sensitive to vibration.

ASK FOR NEW CATALOG 9-PS FREE

PRESSURE SWITCH DIVISION

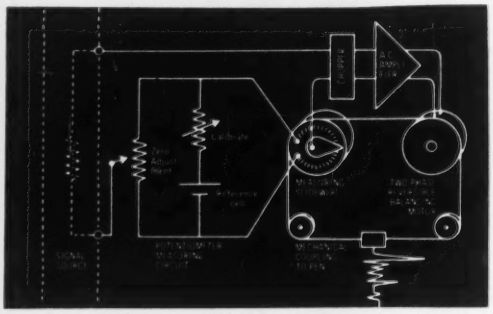
Barksdale valves

5125 Alcoa Avenue, Los Angeles 58, California

CIRCLE 50 ON READER-SERVICE CARD

Strip Chart Recorders

The time-proven potentiometer measuring circuit and automatic null-balance principle is used in both the Varian G-10 and G-11A recorders . . . The measuring circuit contains a calibrated source of voltage against which the data signal is compared. The difference (momentary error signal) between the



data-signal voltage and the measuring-circuit voltage is converted by the chopper to an a-c balancing signal. This balancing signal has phase and amplitude determined by polarity and magnitude, respectively, of the error signal. It is amplified and applied to one winding of a two phase balancing motor the other being excited from the a-c line. Phasing is such that the motor will drive the measuring slidewire contact in the direction required to reduce the error signal to zero. The slidewire contact position therefore indicates the amplitude of the input signal and the pen is coupled to this contact . . . (*From new 8-page bulletin, Varian Assocs., 611 Hansen Way, Palo Alto, Calif.*)

FOR THIS LITERATURE CIRCLE 177 ON READER-SERVICE CARD

Environmental Equipment

The current trend in requirements for environmental test equipment has been largely dictated by the rapid advances made in aircraft and missile design and appears to have two components, a trend towards larger facilities in which complete assemblies and systems rather than components may be tested, and a trend to-

41. ENVIRONMENTAL TEST EQUIPMENT

TABLE 6. MISSILE ENVIRONMENTAL CRITERIA

Environment	*Present*	*Intermediate*	*Future*
Temperature	−65 F to 200 F	−65 F to 1,000 F	−65 F to 2,000 F
Temperature Shock	−65 F to 200 F 15 min	−65 F to 1,000 F 5 min	−65 F to 2,000 F 5 min
Altitude	100,000 ft	3,000,000 ft	3,000,000 ft
Altitude Shock	0–50,000 ft 10 sec	0–3,000,000 ft 20 min	
Mechanical Vibration	5–55 cps 55–200 cps	Possible complex wave	
Acoustical Vibration	150–175 db	153–178 db	138–183 db

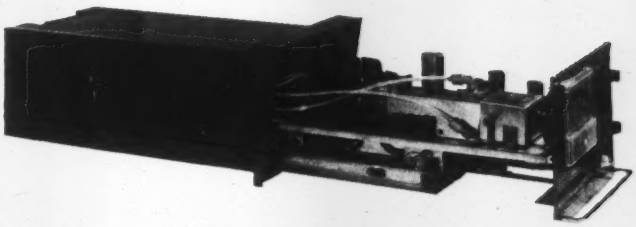
wards facilities in which several different environments may be created simultaneously . . . To this end, design requirements have been formulated for equipment capable of producing much higher rates of change of temperature, capable of producing temperature, altitude, vibration, and acceleration simultaneously, and other combinations of conditions . . . . (*From new 24-page Reprint of Chapter 41, 1959 titled "Environmental Test Equipment, ASRE Data Book, Vol. 1, Missimers Inc, 3737 San Fernando Rd., Glendale 4, Calif.*)

FOR THIS LITERATURE CIRCLE 178 ON READER-SERVICE CARD

NEW M-S-A® LIRA MODEL 300

MINIATURIZES

INFRARED GAS ANALYSIS



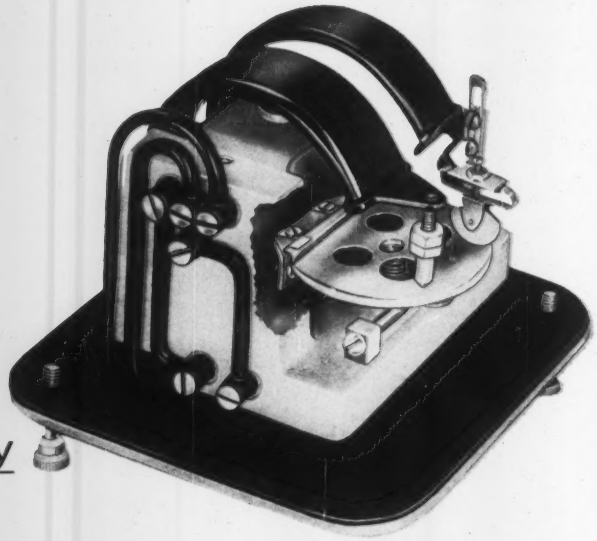
Instrument Engineers asked MSA for a modern, low-cost infrared analyzer that would substantially reduce the bulky, high-cost complexity of most available instruments. They were searching for something inexpensive. More compact. Less complex. Lightweight and portable. Several sizes smaller. Yet this boiled down dream model had to have the inherent reliability and accuracy of an infrared analyzer. A tall order, indeed. But we filled it with a pint-sized package: the new M-S-A LIRA Analyzer Model 300. 9⅛" wide. 6¾" high. 18$\frac{9}{16}$" long. Mounted on a single roll-out tray. It *miniaturizes* infrared gas analysis.

Write for detailed technical bulletin

INTERNATIONAL DIVISION
Mine Safety Appliances Company
Pittsburgh 8, Pennsylvania

See the low-cost LIRA Model 300 at the Instrument Show, Booth 604.

CIRCLE 51 ON READER-SERVICE CARD



NEW high sensitivity ASHCROFT PNEUMATIC TRANSMITTERS

lower costs...reduce maintenance ...provide tighter control

Ashcroft Non-Indicating Pneumatic Transmitters are made in pressure and temperature types, each in regular and short span. Operation is on low-pressure air: output range, 3-15 psi or 3-27 psi.

These new transmitters are designed around (1) a powerful, efficient relay with sensitivity high enough to operate controllers, and (2) a simple, dual Bourdon tube motion-balance system. High sensitivity permits the use of narrowest proportional band settings on controllers and allows instant controller response to deviations from set point. With a shorter transmission lag, automatic corrective action starts before the deviation becomes critical.

In manual control systems, these new Ashcroft Transmitters (teamed with suitable receivers) make it practical to operate boilers at the most efficient level. In wet processing operations, fractionating columns yield a purer product. Highly suppressed Ashcroft Short Span Transmitters are so sensitive they can "judge" entire control loops and detect any errors in the system.

Basically a 6″ cube, lighter than most 8½″ pressure gauges, these climate-proof Ashcroft Transmitters are simple to install in cramped locations, are most readily accessible for adjusting or service. Calibration is extremely easy, with linearity checking entirely eliminated. Most parts in all types in the line are interchangeable. Ask your nearby Ashcroft Gauge Distributor about the lower initial costs and other savings that follow when you install Ashcroft Non-Indicating Pneumatic Transmitters. Send for Bulletin 361.

MANNING MAXWELL & MOORE INC. M&M TRADE MARK

ASHCROFT PNEUMATIC TRANSMITTERS

A product of

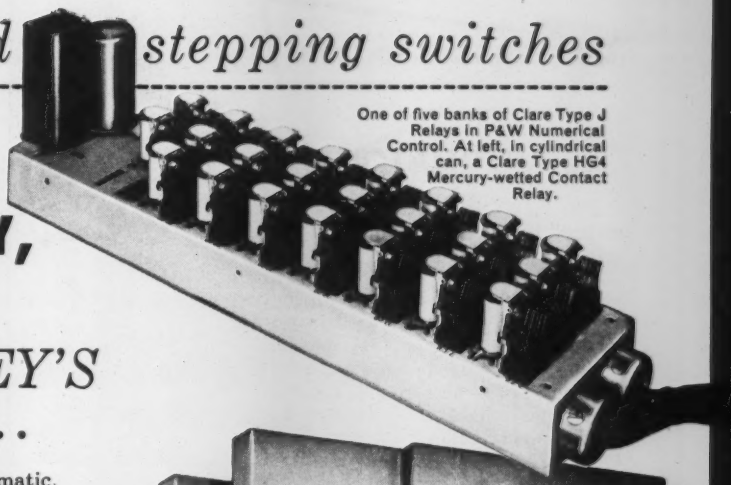
MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

CIRCLE 52 ON READER-SERVICE CARD

CIRCLE 53 ON READER-SERVICE CARD →

CLARE relays and stepping switches



One of five banks of Clare Type J Relays in P&W Numerical Control. At left, in cylindrical can, a Clare Type HG4 Mercury-wetted Contact Relay.

INSURE ACCURACY, INCREASE RELIABILITY, REDUCE SIZE *of*

PRATT & WHITNEY'S Numerical Control...

Pratt & Whitney's Numerical Control is a fully automatic, ultra-precise means of translating blueprint data into a series of machine positions. Applied to jig borers and other precision Pratt & Whitney machine tools, settings are made quickly, with high reliability to .0001" accuracy.

In operation, the Planning Engineer transfers to a Numerical Planning Chart all dimensional data from the blueprints which are necessary to determine the positions. Ordinary clerical help then punch these data into a tape. Machine positionings are then controlled by the tape or, when required, by a dial on the Operator's Console.

Here is what P&W's Mark H. Sluis has to say about the vital part played by Clare Relays and Stepping Switches:

"In the 4EA Numerically Controlled Jig Borer, punched-tape information is decoded by Clare Type J Relays and fed to a storage bank of 25 Clare Type 11 Stepping Switches. The selection of the proper storage switch is accomplished by a distributor—a Clare Type 26 Stepping Switch. In addition to storing the required command data for the slide positioning of this machine, logic circuitry comprises some 115 Clare Type J Relays.

"For ultra-reliability of the digit-selection circuitry, a dozen Clare Type HG4 four-pole Mercury-wetted Contact Relays are utilized.

"Through use of the Clare relays and stepping switches, our circuitry has increased in reliability, and a large contribution was made which enabled us to realize a 6:1 size reduction of the control system."

A Pratt & Whitney 4EA Numerically Controlled Jig Borer.

For complete information on Clare Relays and Stepping Switches contact C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., P.O. Box 134, Downsview, Ontario. Cable Address: CLARELAY

CLARE RELAYS *First in the Industrial Field*

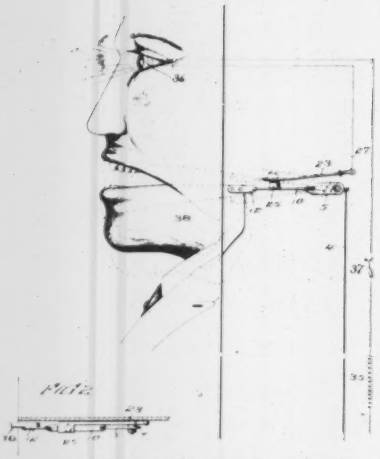
panhandle pete

AUTOMATON

This invention relates to automatically operated mechanism for actuating automatons.

The object of my invention is to provide a motor mechanism adapted to be connected to an electric circuit to actuate automatic devices such as toys, automatons and motion figures adapted to be used for advertising purposes, fans, signals, etc., the motive power being applied through the instrumentality of the expansion and contraction of a wire under the influence of an electric current.

Normally the parts are held in the position indicated by the full lines in Fig. 3, by the tension of the wire 4. When the electric current is supplied to the mechanism through the leads the current passes from the lead 27, through bar 1, the spring plate 23, contact 25, spring 10, lever 5, and wire 4 to the lead 28. The wire 4 being of high resistance becomes rapidly



heated and expands, thereby relieving the tension on lever 5, which is immediately drawn to the left by the weight 30. Inasmuch as the leaf spring 10, yields under the action of the weight and its momentum and bends in the manner illustrated in dotted lines, this causes the bar or link 12 to be carried considerably beyond the position it would have assumed had it not been for the effect produced by said yielding spring. In thus moving to the left the spring 10, causes the circuit to be broken at the contact 25. By reason of the large radiating surface throughout the length of the wire 1, it becomes chilled and contracts very quickly after the cessation of the current, exerting a strong pull upon the lever 5, causing the parts to return to their normal position and by reason of the yielding of the spring 10 and 23, the momentum of the weight 30, causes the link 12 to swing in the same direction considerably beyond the normal position, as indicated in dotted lines. By the time the parts have reached the limit of swing to the right the current being again closed at the contact 25, the wire 4, becomes heated and expands, so that when the tension of the springs 10 and 23, starts the parts back toward normal intermediate position the weight 30, will be free to continue the swing in the same direction. It will be seen, therefore, that as long as the current is supplied to the device, the weighted link arm 12 will vibrate back and forth. The time of the vibration can be regulated by adjusting the position of the weight 30 upon arm 12.

Milton H. Shoenberg
Patent 1,292,105
Patented Jan. 12, 1919

MINIATURE ROTARY SWITCH

ESCO Type MA-12 is a miniature rotary switch designed for applications requiring 3 amperes 115 v.a-c rating.

This fungus-inert, corrosion-resistant rotary switch is designed to meet MIL-S-3786.

TYPE MA-12

ACTUAL SIZE

- Sections – up to five sections
- Poles – up to 6 poles per section
- Electrical rating – 3 amp. 115v. a-c continuous; ½ amp. interrupting
- Voltage breakdown – 1000 volts RMS
- Positions – 2 to 12 positions per section

Sections and rotors molded of MA 1-60, per MIL-M-14E. Current carrying parts are made of silver-alloy. Designed for single-hole panel mounting. The shaft is ¼" in diameter. Write for Bulletin No. 14 for further information.

ESCO of WEYMOUTH
ELECTRO SWITCH CORPORATION
167 King Avenue, Weymouth 88, Massachusetts

CIRCLE 54 ON READER-SERVICE CARD

NEW 72-page GAGE and CONTROL Catalog

..tells where to use them..
..WHY and HOW!

Illustrates instruments and gages...*diagrams* their installation and on-the-job use... *charts* valuable performance data.

For the efficient measurement of combustion • draft • pressure • flow • vacuum • co_2 • smoke • velocity • static pressure • pressure differential • temperature • and others.

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Dwyer CONTROLS GAGES

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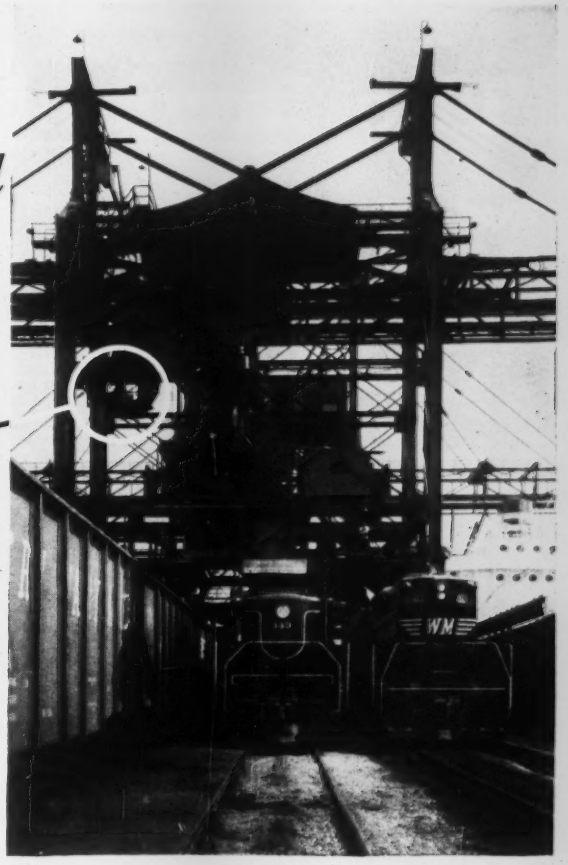
P.O BOX 373-S, MICHIGAN CITY, INDIANA

CIRCLE 55 ON READER-SERVICE CARD

Automation from crane to customer's office at the Western Maryland



After unloading ore from ship to railroad car, weighman in crane transmits data to yard office for automatic preparation of waybill and other documents.

Teletype Printer in a crane automates ore waybilling

As ore is transferred from ships to railroad cars at Western Maryland's Port Covington docks, a weighman high up in the control cabin of the ore-unloading crane records the lot number, tonnage, and car data on a Teletype Printer. Instantly, this information is reproduced in the yard office in punched tape—starting the automatic writing of waybills by a combination of Teletype page and tape equipment.

The only manual intervention following the transmission of the variable data from the crane is the association of fixed-data tapes by the yard clerk. The entire procedure takes just minutes—so that when the last car is coupled to the train, all waybills, arrival notices, and consignees' copies are ready. Accuracy is improved, too—since mechanization eliminates recopying errors.

As a by-product of waybill preparation, a master tape is punched automatically, which is used to produce a complete shipping statement. The system also enables the Western Maryland to give customers an extra service to speed their own accounting procedures: advance direct wire transmission of shipping statement data by Teletype equipment or a duplicate of the master tape by mail.

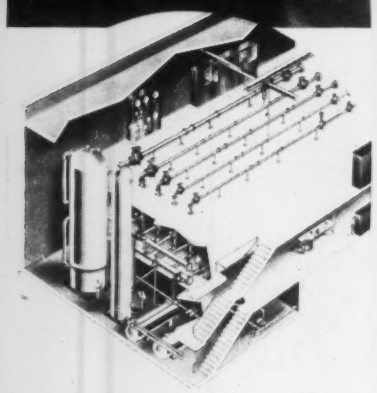
This installation is just one example of how railroads today are using Teletype equipment in new, imaginative ways to trim costs, improve service. This unusual application is made practical by the ruggedness built into Teletype equipment, so that it functions dependably and economically even in the dust-generating environment of ore-loading operations. If you would like information on the new Teletype Model 28 Line, please write to: Teletype Corporation, Dept. 23-J, 4100 Fullerton Avenue, Chicago 39, Illinois.

TELETYPE®
CORPORATION
SUBSIDIARY OF *Western Electric Company* INC.

CIRCLE 56 ON READER-SERVICE CARD

The largest laboratory of

Flowmeters and manometers are just two types of precision equipment used for accurate measurement in this unique laboratory.

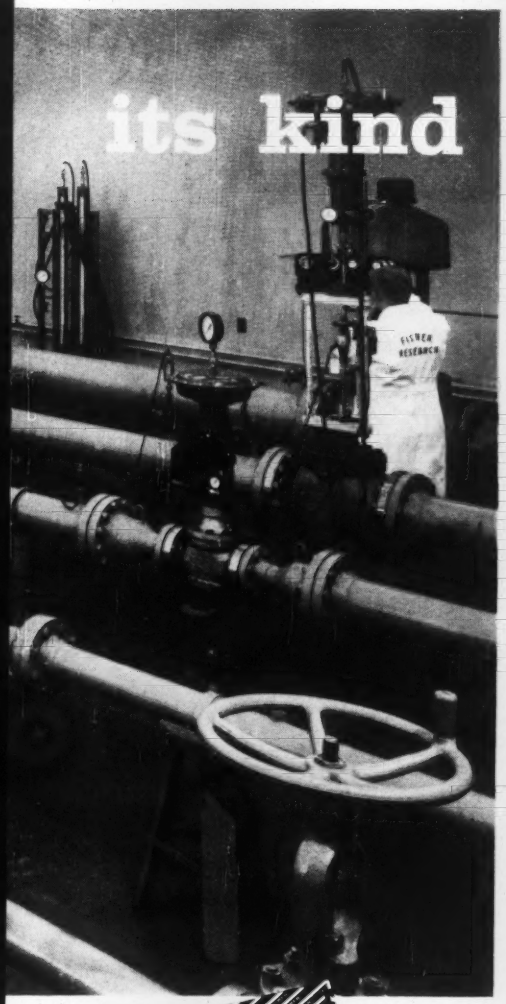


Three full stories are devoted to testing and proving the quality of all Fisher equipment.

A Fisher engineer obtaining frequency response data of Fisher equipment under test on an oscillograph.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD... CHANCES ARE IT'S CONTROLLED BY...

CIRCLE 57 ON READER-SERVICE CARD



its kind in the world

where research engineers develop and perfect the quality of Fisher products

THIS is a remarkable facility. It's the nerve center of a 3-story laboratory built to duplicate every conceivable field condition under which any Fisher product might operate. There's no other like it, anywhere. The engineers shown are keeping keen observation on the operating characteristics of such Fisher equipment as pressure regulators, liquid level controls, diaphragm control valves . . . plus many other types. There are literally hundreds of these complex and abnormally rigid tests which Fisher controls are subjected to before they are released to the user.

QUICK FACTS ABOUT THE FISHER LABORATORY

- It is equipped with vessels capable of storage pressures up to 2500 psig. These vessels discharge into five flow metering lines ranging in size from 4 inches to 12 inches.
- It is possible to test with either air or water at 400 psig pressure. One 4-inch line is capable of 2500 psig pressure for air or water testing.
- All flows are metered with orifice plates and differential manometers. Liquid flows can be metered up to 6000 GPM and gas flows up to 7,000,000 SCFH.
- Actual flow test curves are recorded on each Fisher valve design. This gives a visual record of the operating characteristics of each piece of Fisher equipment and proves that its performance in the line will precisely match published data.
- It is an approved laboratory for determining official ASME capacity ratings on safety and relief valves used on unfired pressure vessels.

The end result of these combined facilities and constant vigilance is the building and maintenance of user confidence . . . so that when an instrument man says "put a Fisher in the line" he knows that it will perform as promised and guaranteed.

Send for Bulletin AL-8

This comprehensive booklet contains valve sizing and capacity charts obtained from thousands of actual laboratory flow tests for all Fisher body types and inner valve styles.

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

BUTTERFLY VALVE DIVISION: CONTINENTAL EQUIPMENT CO., CORAOPOLIS, PENNSYLVANIA

FISHER® Controls SINCE 1880

CIRCLE 57 ON READER-SERVICE CARD

Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

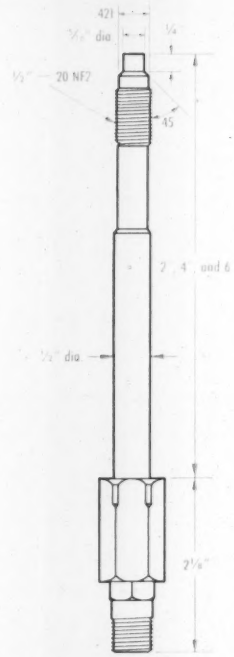
No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

designed
SPECIFICALLY
for the
plastics industry

NORWOOD CONTROLS

PRESSURE NEW TRANSDUCER



Designed to fit widely-used standardized thermocouple mounting dimensions on extruders.

- **high reliability**
- **high sensitivity**
- **high pressure**
- **high temperature**
- **flush mounting**
- **bonded strain gage ruggedness**

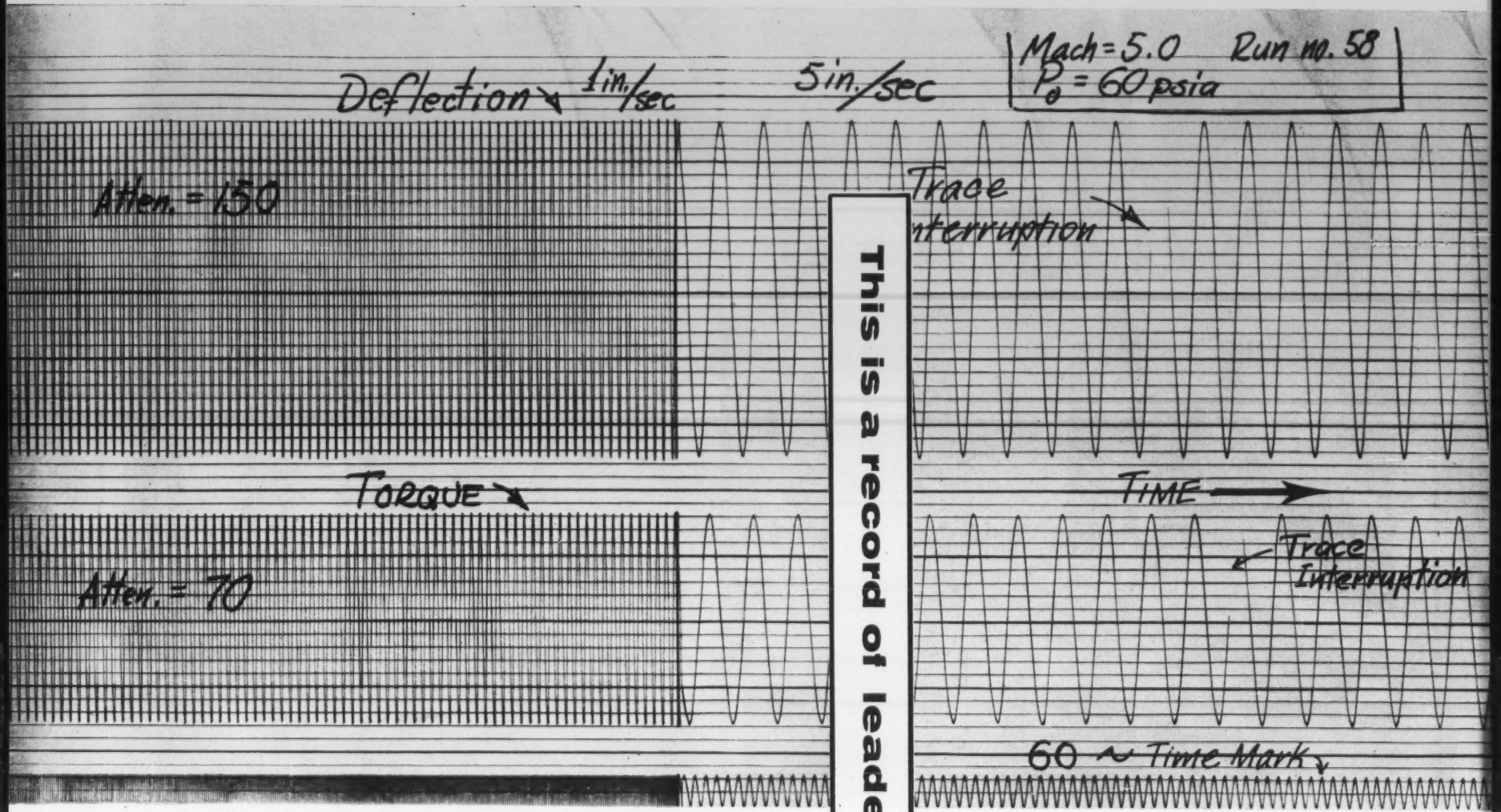
Norwood Controls transducers with high temperature adaptors have been used for several years in plastic extruder research by leading plastic producers. This experience has now been applied to the development of a transducer designed to fit standard production equipment. It possesses the same high performance characteristics as Norwood's well-known engine pressure pick-ups. Write for full technical data . . . Norwood Controls Unit, Detroit Controls Division, 937 Washington St., Norwood, Mass.

See it at ISA Show in Chicago in September

American-Standard
DETROIT CONTROLS DIVISION

MODEL 175

CIRCLE 45 ON READER-SERVICE CARD



Honeywell 906A Visicorder record, actual size. Note longitudinal grid lines and trace identification interruptions.

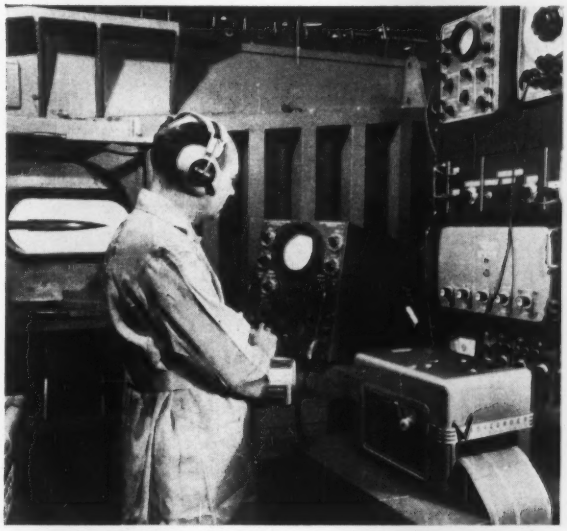
These studies of aerodynamic damping coefficients on an airframe were made by engineers at ARO, Inc. They were conducted in the Gas Dynamics Facility at the U.S.A.F.'s Arnold Engineering Development Center, Tullahoma, Tennessee, wind tunnel center of the Air Research and Development Command.The studies were directly recorded on a Honeywell 906-A Visicorder.

The problem: To measure damping-in-pitch derivatives for a clipped-delta-wing-body configuration over a Mach number range of 2.0 to 5.0 so that these measurements could be compared with the Mach number trend predicted by theory.

The set-up: A model of the delta-wing body, mounted on its cross-flexure pivot support, was forced to oscillate through a linkage by an electro-magnetic shaker. Resistance strain gauges were bonded to the input torque member and to one of the pivot supports. These gauges supplied torque and displacement signals through a carrier amplifier to two galvanometers in the Visicorder. An oscillator, driving a third galvanometer, established a time base for the oscillogram.

The values discovered through this forced-oscillation balance system experiment showed some discrepancies from values predicted by theory, because the theory pertained to simpler bodies than that used in the tests. The experiments provided a new set of data which will result in more accurate predictions for future design.

in aerodynamic research



Z. A. Woodard, Jr., ARO, Incorporated, instrument technician, operates the Visicorder in the measurement of aerodynamic damping coefficients.

The Honeywell Visicorder is the pioneer and unquestioned leader in the field of high-frequency, high-sensitivity direct recording oscillography. In research, development and product testing everywhere, instantly-readable Visicorder records are pointing the way to new advances in product design, rocketry, computing, control, nucleonics . . . in any field where high speed variables are under study.

The new Model 906A Visicorder, now available in 8- and 14-channel models, produces longitudinal grid lines simultaneously with the dynamic traces, time lines, and trace identification by means of new accessory units.

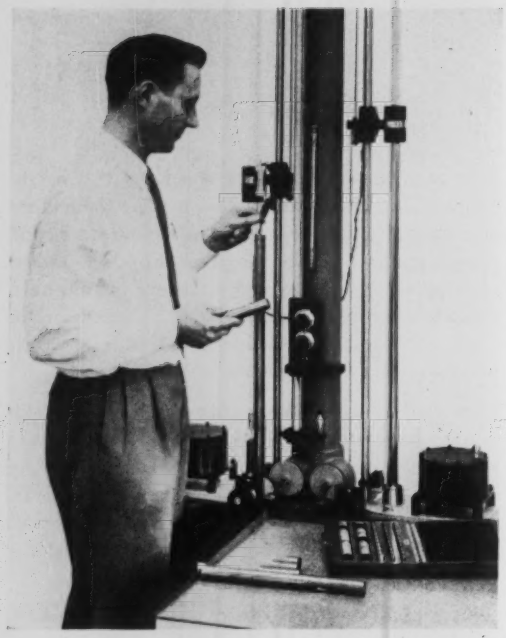
To record high frequency variables—and monitor them as they are recorded—use the Visicorder Oscillograph. Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

Reference Data: Write for Visicorder Bulletin
Minneapolis-Honeywell Regulator Co.,
Industrial Products Group, Heiland Division
5200 E. Evans Ave., Denver 22, Colo.

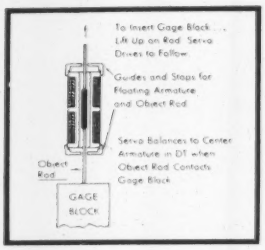
Honeywell

Industrial Products Group

CIRCLE 59 ON READER-SERVICE CARD



Exactel Servomanometers emphasize calibration proving provisions in precision pressure measurement

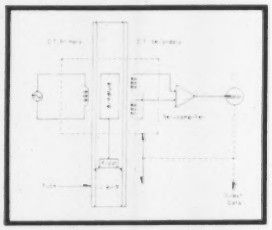


Several years of experience and a great deal of statistical data have now been accumulated on the use and reliability of Exactel's verifying techniques. Customers have been able to prove accuracies of one part in 20 to 50 thousand. For example, three 120 inch range Servomanometers, and a fourth operating as a standard, were recently calibrated in parallel with maximum deviation of 0.004". The calibration proving facilities established the absolute accuracy of the values within this limit.

Exactel instruments may be supplied with three basic provisions for checking and proving of calibrations. The combination of techniques provides a true primary standard wherein the calibration is based upon as well as proved by cgs standards.

The calibration proving provisions, available singly or in total, permit verification of the mechanical accuracy of the follower and readout mechanism, ability of the instrument to read true liquid column height and determination of error in temperature compensation. The methods are described in Exactel Bulletin 500.

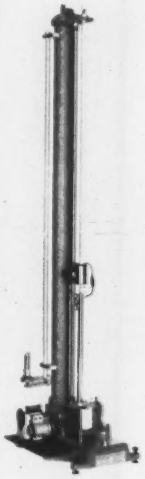
Mechanical accuracy, for example, is proved by the following technique: A second differential transformer mounted on the carriage is equipped with an armature mounted on an "object rod" that is free to float vertically except as guided and restrained by Nylon end bushings. The DT has a connector that may be plugged into the line that ordinarily goes to the DT that senses the float. When the calibration proof DT is used, the servo drives in a direction tending to center the armature when the bottom of the object rod contacts a solid object, normally the base of the instrument serving as a reference surface or the top of a Jo block. Thus by installing Jo blocks and allowing the servo to balance, the overall mechanism may be easily calibrated in a matter of minutes. The height of the stack of Jo blocks is read on the counter (with the inclusion of correction for cistern drop at a known ratio). This particular proving facility, originally offered as an optional feature, has proved so reliable and popular it is now being included as standard equipment.

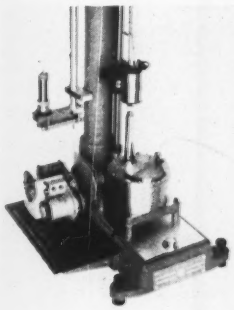


The basic Exactel principle.

A differential transformer (DT) is continuously positioned by a servo to be electrically centered about a float containing magnetic material. A proportional shaft position in the servo transmission is then analogous to the position of the liquid column.

Illustrated at right is uncabineted Model 560IN-D with Analog Temperature Compensation, calibration proving provision, synchro output, counter and area for mounting auxiliary readout and control devices. The lower end of the tube passes through the top of the cistern and terminates beneath the manometer liquid. This constuction is virtually leakproof, provides improved liquid column response, permits removal of the tube without draining instruments, avoids pockets of trapped air that can compress under pressure and offers several other operating advantages. This is one of 38 standard models available in single or dual instrument construction. Many optional features are available, including use of stainless steel manometer tubes and high pressure construction, choice of any liquid and variations in calibration units and servo characteristics.





"Servomanometer" and "Analog Temperature Compensation" are trade names of Exactel Instrument Company.

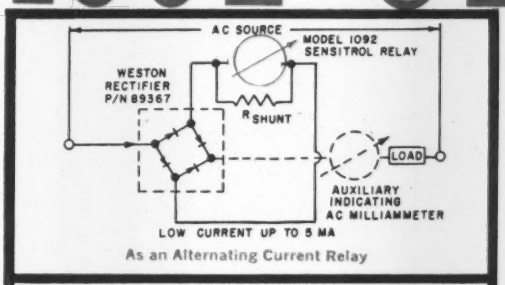
EXACTEL INSTRUMENT COMPANY

185 Evelyn Avenue • Mountain View, California

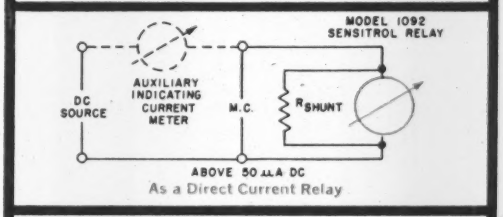
YOrkshire 8-6558

CIRCLE 60 ON READER-SERVICE CARD

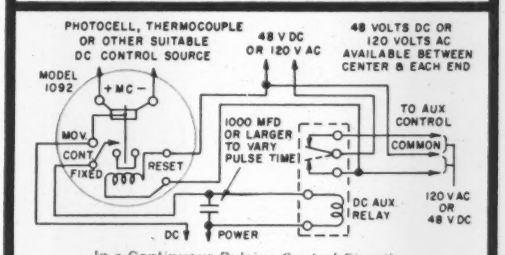
1092 SENSITROL®



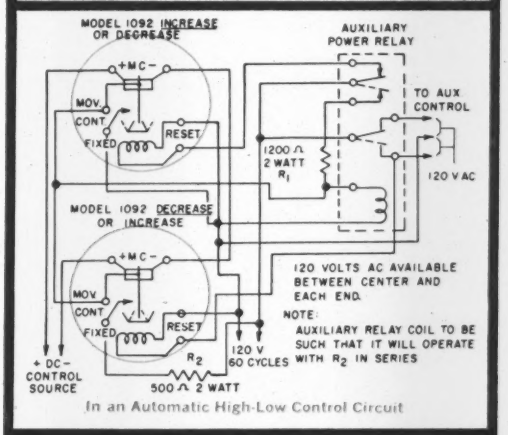
As an Alternating Current Relay

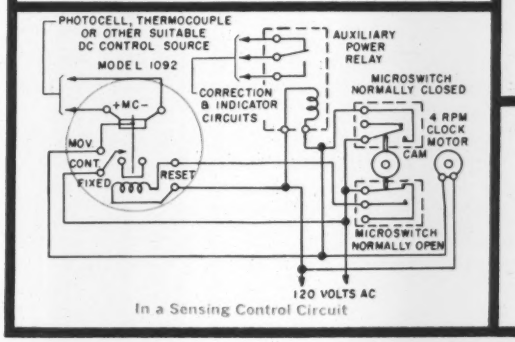


As a Direct Current Relay

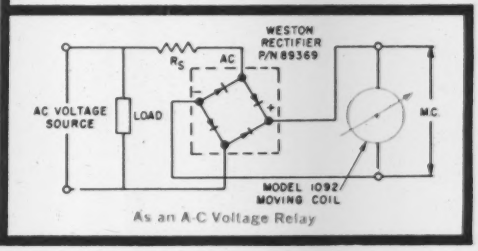


In a Continuous Pulsing Control Circuit


MODEL 1092 INCREASE OR DECREASE
AUXILIARY POWER RELAY
+MC−
MOV.
CONT. FIXED
RESET
TO AUX CONTROL
1200 Ω 2 WATT R1
120 V AC
MODEL 1092 DECREASE OR INCREASE
120 VOLTS AC AVAILABLE BETWEEN CENTER AND EACH END.
NOTE: AUXILIARY RELAY COIL TO BE SUCH THAT IT WILL OPERATE WITH R2 IN SERIES
120 V 60 CYCLES
+ DC − CONTROL SOURCE
R2
500 Ω 2 WATT
In an Automatic High-Low Control Circuit



In a Sensing Control Circuit



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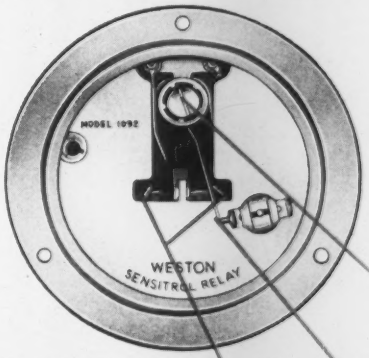

In breadboard circuits, the 1092 makes it unnecessary to pin-point electrical operating values through elaborate calculations or measurements. A single, movable contact adjuster (1) provides variable and accurately repeatable settings. In production equipment, the 1092 eliminates the need for stocking a variety of relays.

Model 1092's contain built-in reset mechanisms (2) and chatter proof locking magnetic contacts (3). They can be set to close at any value of D-C from 5 to 50 microamps, or a comparable millivolt span of 10 to 100 . . and will handle 100 milliamps at 120 volts A-C or D-C.

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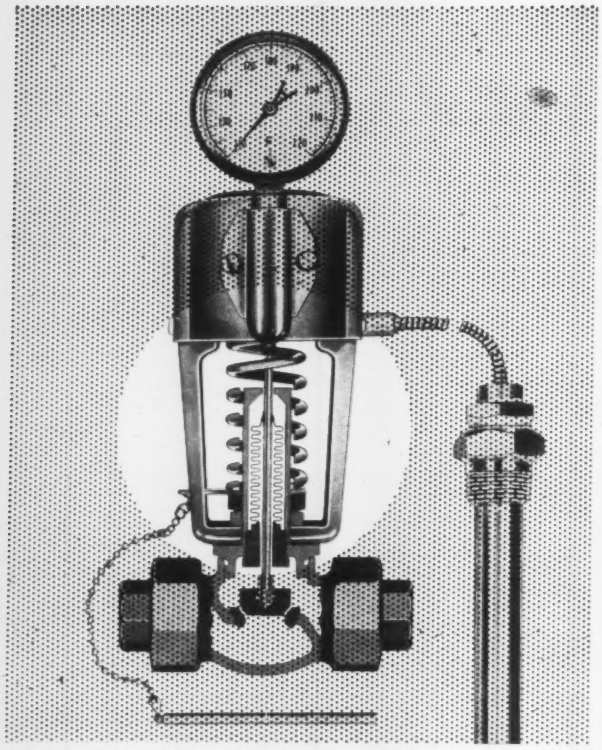

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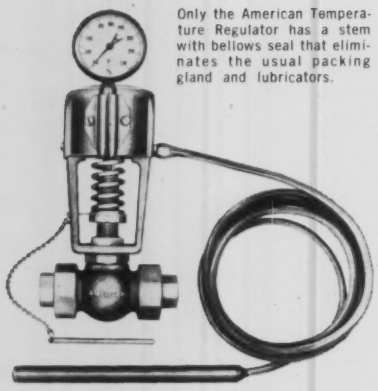

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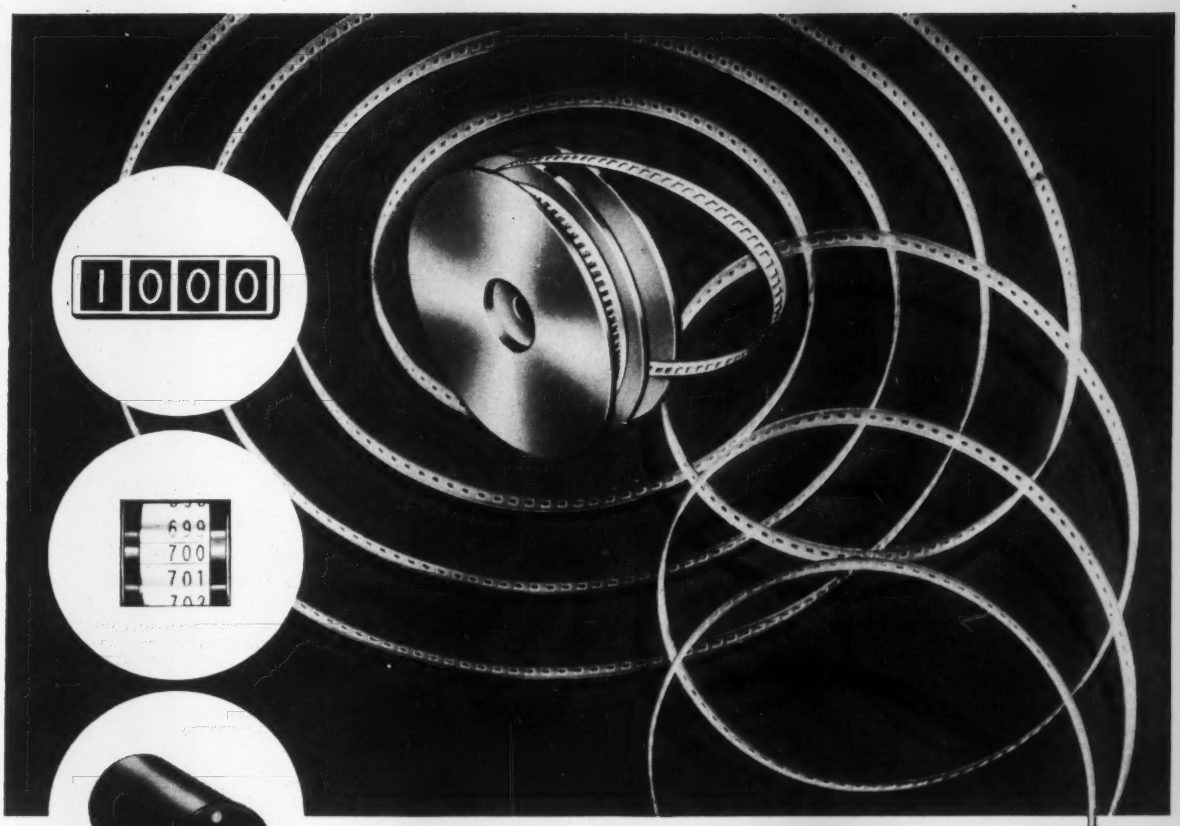

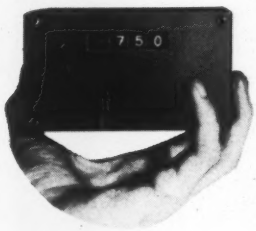

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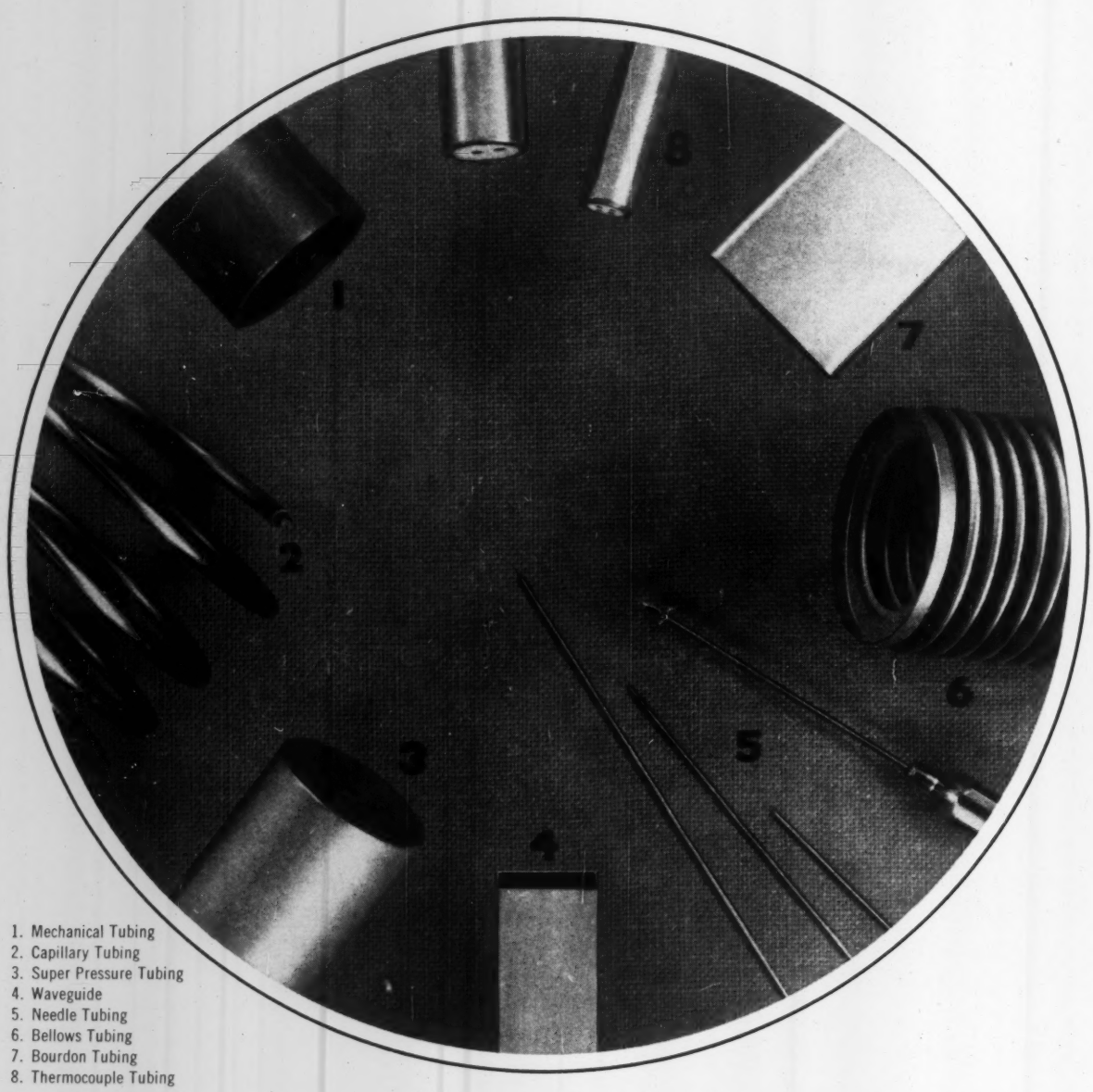
Tubexperience paces



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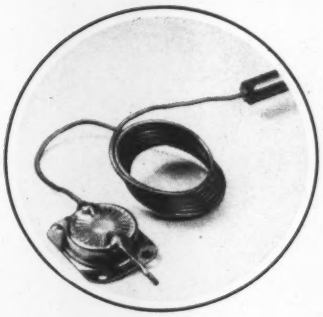

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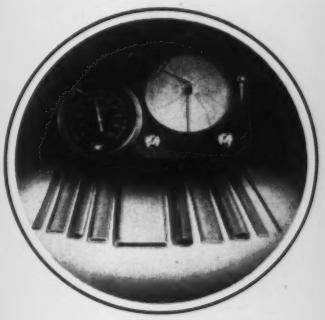

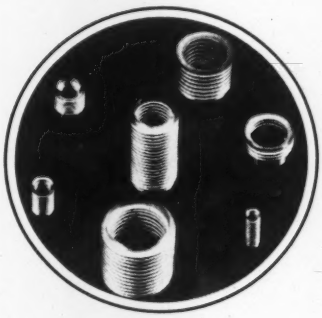

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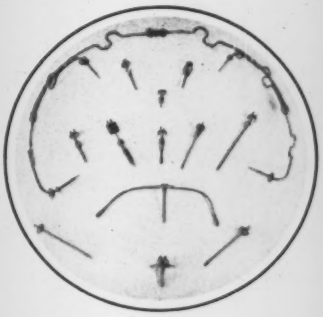

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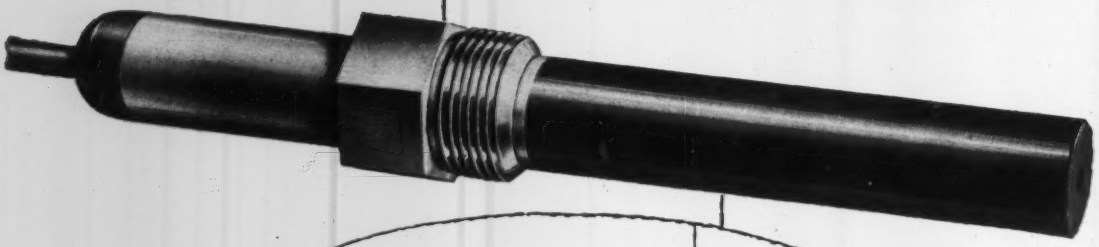

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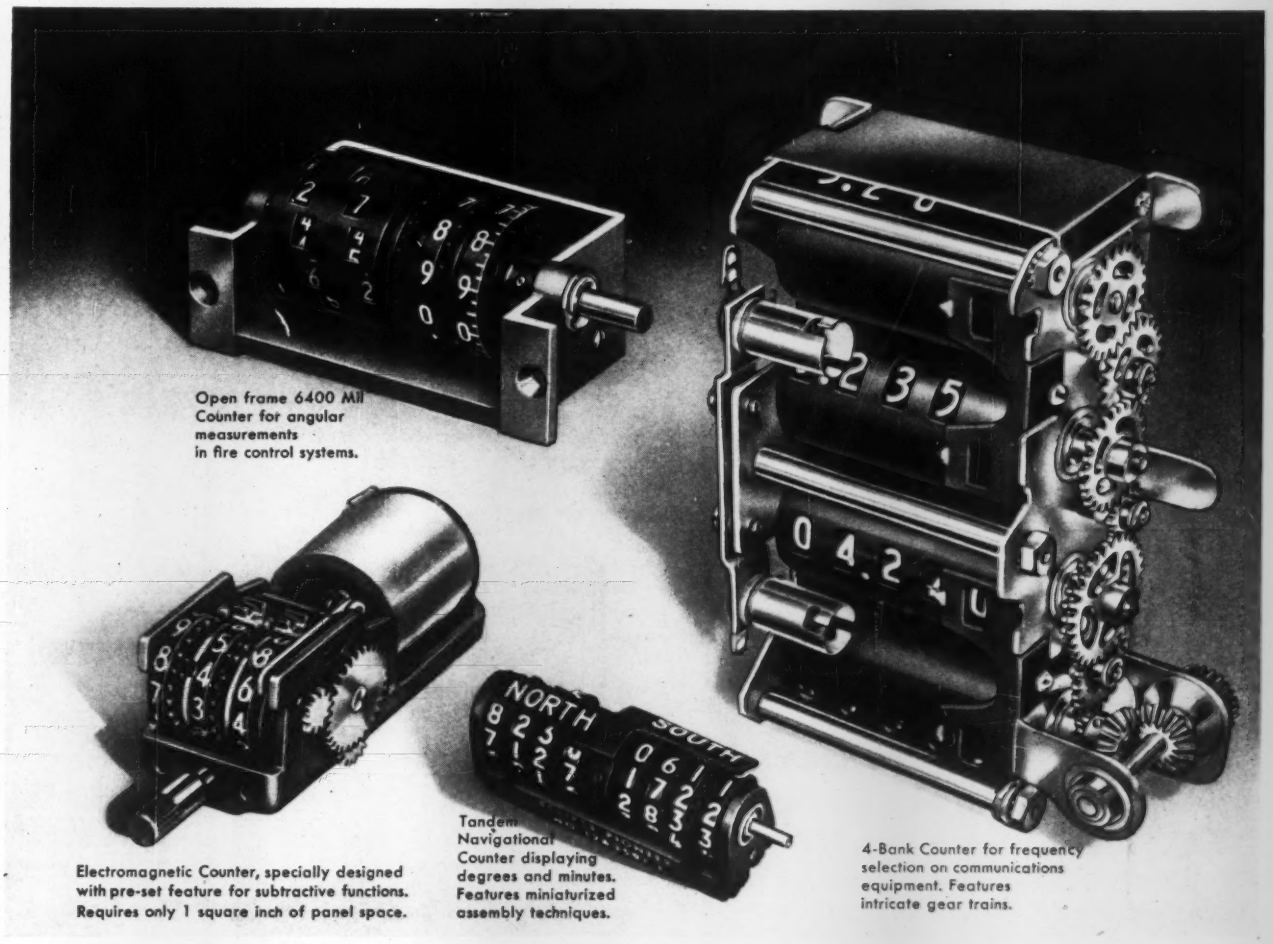

Open frame 6400 Mil Counter for angular measurements in fire control systems.

Electromagnetic Counter, specially designed with pre-set feature for subtractive functions. Requires only 1 square inch of panel space.

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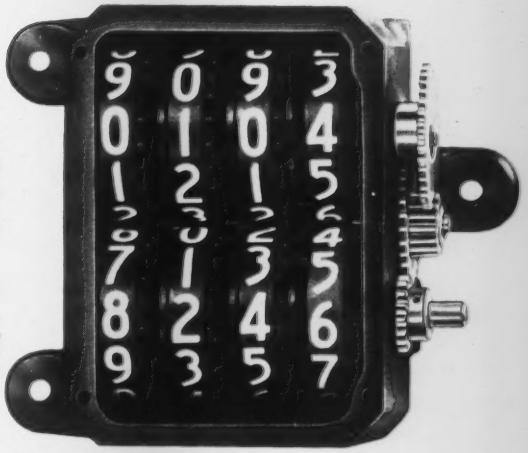

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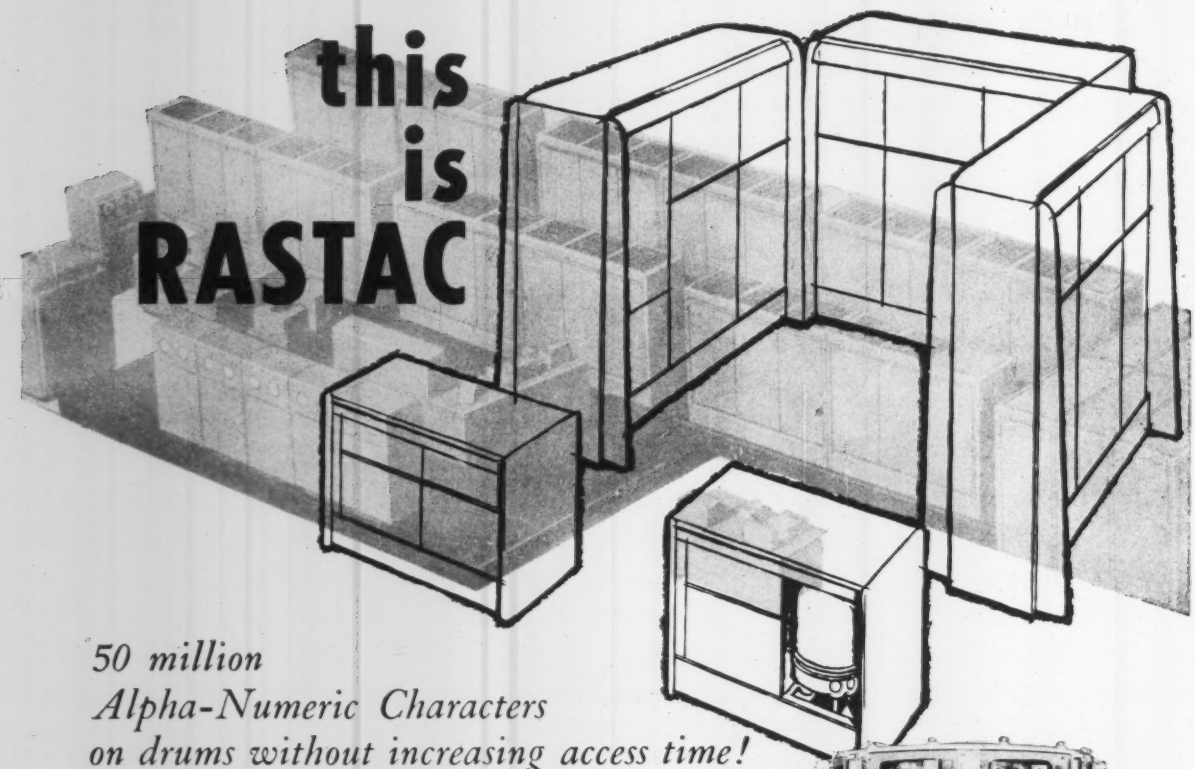


50 million Alpha-Numeric Characters on drums without increasing access time!

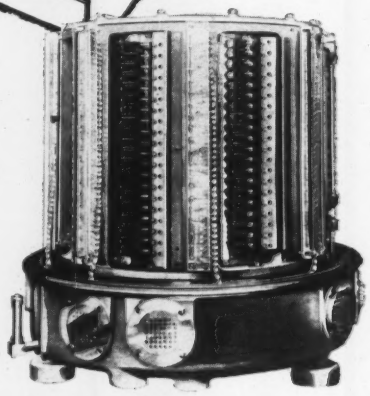
LFE's RASTAC means Random Access Storage and Control in a big way. In general-purpose digital computer applications, it provides mass data storage on an on-line basis. Thus, RASTAC eliminates the "hang-ups" encountered while the computer is searching for data on cards or tape. *Average random access time is only 1/6 of a second, regardless of the size of the system!*

A complete LFE RASTAC System may include from one to thirty-three high density magnetic file drums (LFE Type HD), plus three cabinets of control and power supply elements. So RASTAC is actually a building-block system of reliable magnetic modules.

A RASTAC System can be assembled as a one drum unit with a storage capacity of 1.5 million characters. Or the maximum RASTAC is available with 33 HD drum units for a total storage capacity of almost 50 million characters.

But regardless of the number of drums in use, LFE's RASTAC system always offers an average random access time of 1/6 of a second.

RASTAC is a truly versatile system. In addition to normal on-line operations in conjunction with the Computer, it may also be used independently as a file with the appropriate input and output stations. When used on-line RASTAC may be also equipped with facilities for independent operation during computer down time.



RASTAC can be used in conjunction with any *general purpose digital computer.*

We suggest you consider the RASTAC System if you require fast access to mass data storage. Descriptive literature is available on request. Write to Department **9-1**

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editorial

The Systems Concept

T. M. NOURSE and J. T. McFARLAND, Hagan Chemicals & Controls, Inc.

THE CONCEPT of an automatic power-generating station has gone a lot further and faster than anticipated—perhaps too fast; large sums should *not* be invested today in computer-control-type systems without consideration of *all* the factors involved.

The optimum control-computing system is a compromise between reliability, simplicity, accuracy, sensitivity, payout and cost. From the theoretical standpoint there is no great difficulty in providing a system to automatically put a boiler on line by push-button—but one should carefully consider how many times the unit will be started up in the course of ten or fifteen years. Also, the automatic sequences and hardware to accomplish the desired action should be proved before investing in computer capacity which can only stand idle during the proving period. Although the control manufacturer can supply the automatic start-up system today, he should advise only that amount of control and computing that is economic.

The proved reliability and economy of analog-type controlling elements means that such elements should remain in control of the actual operation; the proved accuracy and speed of analog-to-digital conversion and digital computing means that these techniques should be used for computing and storage of data, including as many of the following functions as are economic—arithmetic functions, logging, scanning, optimizing and programming.

Where electronic computers or data processers are to be used in the system, an electronic control system of high reliability should be used. This indicates solid-state equipment, particularly magnetic amplifiers. The solid-state control system requires less panelboard space, a factor that can be used to advantage. Similarly, the use of a data system-computer may make possible reduced instrumentation for indication or recording.

Only as many steps toward complete optimal control by computer should be taken as are justified both technically and economically. The following are logical steps to take to reach complete *optimal control*. They may be taken one at a time, with the next step taken after the preceding one is field tested, or the complete package could be purchased today from the control manufacturer:

1. Install an electronic (solid-state) analog control system.
2. Install a solid-state scanning-logging data system.
3. Install computer capacity to compute from processed data.
4. Use computed data to optimize the analog control loops.
5. Add programming capacity for automatic start up and shut down.

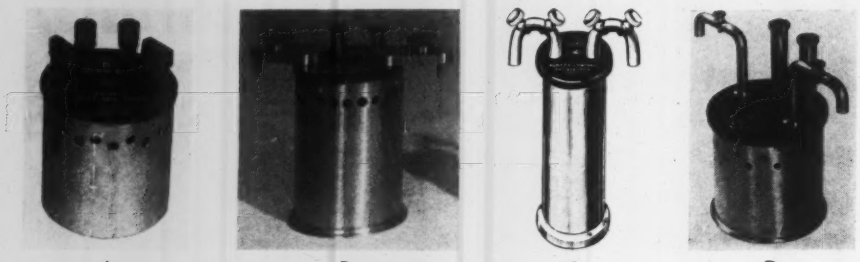
A concluding note: where computer-type optimal control is not required, familiar and conventional pneumatic systems will continue to serve, as in the past.

Creative Thinking

DICKEY DYER, Princeton, N. J.

TOP management does three things—they run the business, they run the key people, and they run the hourly help and what the hourly help does. All top management action is at least three-fold in effect, bearing on the business itself, the key people, and the hourly help, but since all top management action also bears on the present and on the future, its effect is actually at least six-fold. Top management must seek to avoid jeopardizing the future strength of the business in the interest of high returns today; else there may be no continuing business. Top management must seek to avoid jeopardizing the present strength of the business in the interest of high returns tomorrow; else there may be no continuing business.

Then how can "automation" contribute to the decisions and the actions of top management? Certainly it can't make the decisions, and it can't take the actions. What it can do is to speed up the fact gathering process, the experience gaining process, and hence the enrichment of judgement process. This it can do since it can release almost instantly the data it has collected and stored and the skills it has recorded and stored. Automation therefore permits a more adequate control of the present, a less time-consuming preoccupation with the affairs of the present, a better informed perspective on the future, and a greater time availability for consideration of the possibilities for the future.



A B C D

FIG. 1. STANDARD RESISTORS. A shows Physics Research (Otto Wolff) resistor of Reichsanstalt type. B shows L&N resistor (Thomas 1-ohm standard). C shows Rubicon resistor (NBS type). D shows Gray Instrument resistor (Reichsanstalt type).

Resistance Measurement

The most common technique for precision measurement of resistance is bridge technique, using Wheatstone and Kelvin bridges and ratio sets.

MILTON H. ARONSON

TABLE 1—RESISTANCE MATERIALS

	Composition (%)	Resistivity (ohms/cir mil ft)	Temp Coeff of Res/°C	Thermal EMF against Copper (μv/°C)
Manganin	Cu 82-84 Mn 12-13 Ni 4- 5	290	±0.00001 (zero at some temp. between 20 and 30°C)	1.7
Constantin	Cu 60 Ni 40	294	−0.00001	40
Gold-chromium	Au 97.9 Cr 2.1	193	Negligible (20—30°C)	7
Nichrome	Ni 58.5 Fe 22.5 Cr 16	675	0.00022 (0 to 350°C)	20
Karma	Ni 73 Cr 20 Al Fe	800	0.00002 (−50 to + 150°C)	2
Evanohm	Ni 74.5 Cr 20 Al 2.75 Cu 2.75	800	0.00002 (−50 to +100°C)	2

Data from book *Electrical Measurements*, Melville B. Stout, Rubicon Div., Minneapolis-Honeywell Regulator Co., Ridge Ave. at 30th, Phila. 32, Pa.

A RESISTANCE material should have (1) high resistivity, so that it is not too bulky, (2) low temperature coefficient of resistance, so that it doesn't change value with temperature, (3) low thermal emf when connected to copper, the most common connection wire material, and (4) high strength so that it won't break when fabricated into the small dimensions necessary for high resistance.

Iron was the resistance material used by earliest experimenters. Copper, gold, platinum, silver and aluminum, with various percentages of manganese, nickel, and chromium were tried. Eventually six or seven metal compositions were established which represented good compromises between the desired characteristics; these are listed in Table 1. Most modern precision resistors are made of manganin, with Evanohm being considered for the higher values.

The ohm is defined in terms of the mechanical units of length and time. However, the working standards are wire-wound resistors of manganin.

In 1897, standard values were assigned to a group of 1-ohm manganin resistors made at the Reichsanstalt, Germany. From 1910 to 1931 the ohm was maintained at the NBS by manganin 1-ohm resistors developed by E. B. Rosa; since 1931 a resistor developed by J. L. Thomas has been used. Standard

resistors of all three designs—Reichsanstalt, NBS Rosa (or simply NBS), or Thomas—are available commercially (Fig. 1).

The Reichsanstalt type has the resistance wire in a container with holes that permit oil to circulate around the wire; in the NBS Rosa type the resistance wire is in a container sealed with oil so that the atmosphere cannot affect oil or element; the NBS Thomas type is a double-wall unit with the space between the cylinders sealed with dry air. All types should be immersed in a constant-temperature oil bath when in use, for highest accuracy.

Today the unit of electrical resistance for the USA is maintained at the NBS by ten 1-ohm resistors of the Thomas type. The NBS offers a calibration service for resistors intended for use as secondary standards*.

Fig. 1 shows commercial standard resistors. A shows an Otto Wolff** unit with resistance of 0.01 absolute ohm. B shows an L&N Thomas-type*** 1-ohm unit. The NBS will *certify* the Thomas 1-ohm standard to 2 parts in a million; it will *measure* it and other resistors to 1 ppm.

Standards-quality resistors (accuracy of 0.01% or better) are commercially available with values from 0.00001 ohm to 100,000 ohms and higher. They are used in comparison-type resistance measurements, in calibration of precision bridges, and as shunts in potentiometric current measurement. When used with higher currents as shunts, they should be kept in cooled oil baths.

The two basic techniques for the measurement of resistance are (1) *measurement of current* through the resistor with an ohmmeter, voltmeter-ammeter or potentiometer, and (2) comparison against calibrated resistors by means of bridge technique.

Measurement

Ohmmeter

Measurement of the resistor by ohmmeter is the more rapid but less accurate technique. Even when accurate bridge measurement is to be used, an ohmmeter can be used to obtain an approximate resistance in order to save time.

The ohmmeter (Fig. 2) is usually a 1-ma permanent-magnet moving-coil movement with a series and shunt resistor and a source of potential. When the unknown resistance X completes the circuit, the current is inversely proportional to X, and the scale can be calibrated directly in ohms. The scale has infinity ohms at the 0-current end, and 0 ohms at the other end.

The accuracy is limited by (1) the meter accuracy, (2) the difficulty of reading the nonlinear hyperbolic-

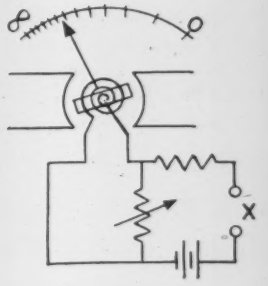


FIG. 2. OHMMETER movement.

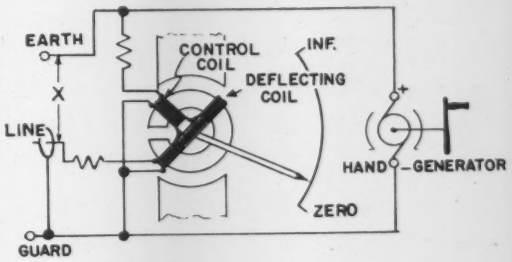


FIG. 3. "MEGGER"-type crossed-coil ohmmeter.

shaped scale with its crowded graduations at the high-value end, and (3) the instability of the voltage source. The latter requires that input leads be shorted before each use and the shunt adjusted to give a 0-point calibration; the input is then opened to adjust the infinity-point. Accuracy is seldom better than 1% to 5%; even this can be obtained only over portions of the scale within limited ranges. Megohm values are difficult to measure by ohmmeter because the self-contained source of emf is limited in value and the scale is crowded at its upper values.

Differential Galvanometer

An ohmmeter for high resistance that uses a *crossed-coil movement* is shown in Fig. 3. The torques of the coils oppose each other. One coil (the left deflecting coil) is in series with the generator *and* the unknown resistor; the other coil (the control or current coil) is in series with the generator. As the torques oppose, the effect of the generator voltage cancels, and the deflection is proportional only to the unknown resistance X. In the "Megger" type shown, a hand generator is used to develop a high energizing voltage (several thousand volts) so that high resistances (hundreds of megohms) can be measured.

A crossed-coil movement can be used also as a *resistance ratio comparator* (Fig. 4). The pointer indicates the *ratio* of the current in coil A to the current in coil B. As the resistor in series with coil A is fixed, the current in A is proportional to the applied voltage E. The current in coil B is I. Hence the ratio (current A/current B) is proportional to E/I and the scale can be calibrated directly in ohms. The advantage of this technique is that the reading is independent of the applied voltage or current, and the unknown resistance X

*Test Fee Schedules of the National Bureau of Standards, U. S. Dept. of Commerce, NBS, Washington, D. C.

**Available from Physics Research Laboratories, Inc., Wolff lists accuracy of Thomas-type resistors as ±0.01%, but NBS certifies them to ±0.005%.

***Thomas type is 1.0-ohm only.

is measured while the current flows through the resistor. This technique also can be used where a resistor must be measured with a *specified* current flowing through it.

Voltmeter-Ammeter Method

A resistor can be measured to about 1% accuracy by measuring the current through it and the voltage across it with ½% meters (Fig. 5). The voltmeter can be connected either to point 1 or point 2; when using point 2 an error results from the fact that the voltmeter draws current; when using point 1 an error results from the fact that there is a voltage drop across the ammeter. Point 1 is best when measuring a large resistance (I is small), point 2 is best when measuring small resistance (E is small). If the meter effect is to be compensated, the following formulas can be used: $X = E/(I - E/R_v)$ when using point 2; $X = (E/I) - R_A$ when using point 1, where R_v = resistance of voltmeter, R_A = resistance of ammeter.

Potentiometer

Use of a potentiometer to measure the resistance is shown in Fig. 6. Here the potentiometer measures the voltage drop across a known or standard resistor to determine I, and then measures the voltage drop (E) across the unknown. X then equals E/I. Although capable of high accuracy, this method is not used much because (1) it is difficult to maintain constant current to a high accuracy and (2) with small resistors a large current must be used, which can heat the resistor. Hence the bridge method is the most common and preferred method for resistance measurement when accuracy better than 1% is desired.

Wheatstone Bridge

The Wheatstone Bridge (Fig. 7) is the most common bridge circuit. The unknown (X) is measured by balancing the bridge so that no current flows through the detector galvanometer. At balance:

$$XB = RA$$
$$X = R(A/B)$$

Arms A and B are called *ratio arms* and usually have unit values of 0.1 ohm, 1 ohm, 10 ohms, 100 ohms, 1000 ohms, 10,000 ohms. Hence the value of the ratio A/B can be 10^5, 10^4, 10^3, ... 10^{-4}, 10^{-5}. The variable arm R (or *rheostat arm*) is usually made up of decades of resistors from 10^{-1} to 10^4 ohms. Note that the maximum value of C is 10^4 and that of (A/B) is 10^5. Theoretically such a bridge could measure resistance from (10^4) (10^5) ohms. Similarly the minimum measurable value appears to be (10^{-1}) (10^{-5}) ohm. Actual use, however, is limited to values of resistance from about 0.1 ohm to 10 megohms because at higher resistance values the detector is relatively insensitive to the low currents, and surface leakage also occurs; at lower values the resistance of leads and binding posts introduces error. However, if a guard circuit is used, and if insulation resistance is above 10^{12} ohms, resistances to 10^9 ohms can be measured.

The accuracy of the technique depends primarily on the accuracy of the bridge resistors. Other possible sources of error are (1) thermal-contact-type emf's, (2) I^2R heating of the resistors, (3) poor balance due to operator error or insufficient galvanometer sensitivity, (4) lead and contact resistance, (5) surface leakage owing to high resistance or high humidity.

As I^2R heat must be kept low, **the specified safe current for a bridge should always be known and never exceeded when using a bridge.**

As the bridge is symmetrical, the battery and galvanometer are interchangeable. The maximum sensitivity results when the 4 arms are of the same order of magnitude. Although unequal ratio arms must often be used to cover a wide range of unknown resistance, it is best to use equal ratio arms with a larger variation of calibrated resistor R. R (called the rheostat arm or calibrated arm or standard arm) usually can be varied in 0.1-ohm increments from 0.1 ohm to 999.9 ohms.

The resistances are switched by dials, plugs, rotary switches, or combinations, as shown in the typical bridges shown in Fig. 8. *Switch zero resistance* becomes important for low-resistance measurements. Otto Wolff reports that usual zero resistance for the Wolff dial switches is between 0.00015 ohm and 0.0002 ohm per dial. The usual zero resistance for the plug

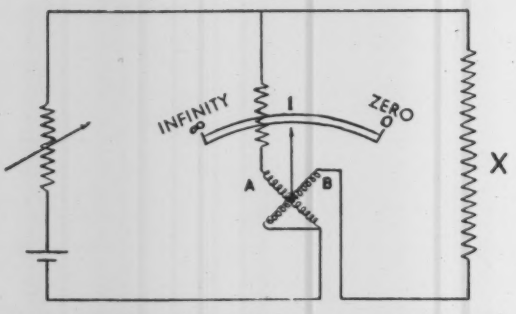


FIG. 4. RESISTANCE RATIO comparator using differential-galvanometer movement. (Courtesy Sensitive Research Instrument Corp.).

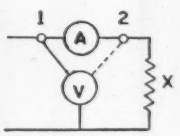


FIG. 5. VOLTMETER-AMMETER method of resistance measurement.

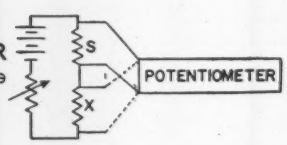


FIG. 6. POTENTIOMETER can be used to measure resistance.

type switches is 0.00004 ohm per plug. The usual total zero resistance (including all *internal* connections and leads) is 0.001 ohm per decade. These figures are all maximum figures and may be reduced in individual cases. For example, it is not unusual for the *total* zero resistance of a 6-dial bridge to be of the order of 0.0035 ohms to 0.004 ohm (values substantiated on many tests by many organizations all over the world).

The advantage of the plug type switch is obvious—low zero resistance. But it saves only 10 to 15 percent in the total "zero" error of the bridge, and in use it may not offer nearly the degree of repeatability which a dial switch offers. The dial switch also is much more nearly independent of the operator.

Fig. 8A shows the L&N 4232-B guarded Wheatstone bridge with plug-and-block-controlled ratio arms (behind window). It is accurate to 0.001% at 25°C; rheostat dials at top are correct to 0.005%; bridge error at 25°C, with a minimum of 1000 ohms in rheostat arm, is ± (0.01% + 0.001 ohm) up to 1.11 megohms, ±0.02% to 111 megohms; 0.2% to 1111 megohms, ±2% to 11,111 megohms.

Fig. 8B shows the Otto Wolff 6-dial Model MW31 Wheatstone bridge with accuracy of 0.01%, range from 0.1 ohm to 100 megohms. On all 6-dial Wolff bridges there is a double set of ratio arms. This is the so-called Schöne arrangement. The Schöne arrangement permits all measurements to be checked by two independent readings. This is done by using the two columns of resistors, I and II. The first measurement is made using $(a/b)_I$ and the second is made using $(a/b)_{II}$.

Fig. 8C shows the Rubicon 1081 Wheatstone bridge; which selects ratio arms by plug switch (top); rheostat has 5 decades.

Fig. 8D shows the Gray Instrument E-1005 Wheatstone bridge, which also selects ratio by plug switch.

Fig. 8E shows the portable EPIC bridge with range from 0.05 to 50,000 ohms.

Fig. 8F is the Shallcross 638-R, which can be used as a Wheatstone or Kelvin bridge.

Wheatstone bridges are available for measurements to above 10,000 megohms, but the accuracy at the upper values depends on leakage and accuracy of adjustment. A guarded bridge (with guard ring) can be used to reduce leakage current, and a vacuum-tube detector rather than a galvanometer can be used to increase accuracy of adjustment. For example, the L&N 4232 bridge has accuracy of ±2% at 11,111 megohms using an electronic detector; ±10% using a galvanometer.

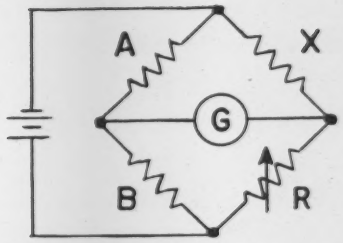


FIG. 7. WHEATSTONE BRIDGE comprises battery, detector, and 4 arms. The unknown (X) is in one arm; the other 3 arms are balancing arms. Arms A and B are called ratio arms; arm R is calibrated rheostat or standard arm.

The selection of *null instrument* is important to accurate resistance measurements. Ideally all the resistances involved in the measurement should be matched. For example, if the unknown resistance is approximately 100 ohms then the ratio should be set at 100:100 and the internal resistance of the galvanometer should also be 100 ohms. Obviously, it is impossible to match a galvanometer to every set of readings made on a bridge. Where possible, however, the galvanometer resistance should be of the same order of magnitude as the measurement to be made.

Kelvin Bridge

It has been mentioned that the Wheatstone bridge should not be used for resistance of small fractions of an ohm because the contact resistance of the switches that control the standard calibrated resistance can be of this order of magnitude. The Kelvin double bridge, or Kelvin bridge, is used for the measurement of resistance from 1 ohm to 10^{-8} ohm and lower.

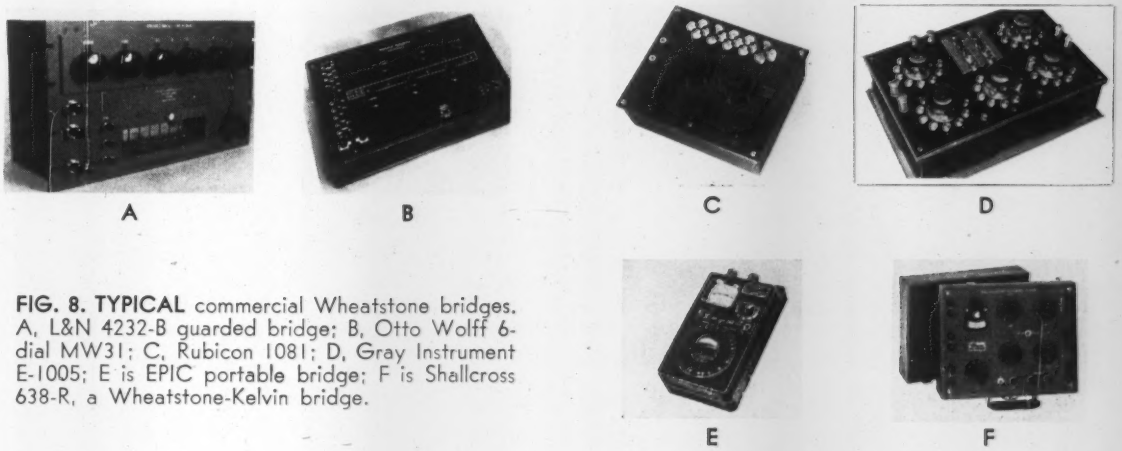


FIG. 8. TYPICAL commercial Wheatstone bridges. A, L&N 4232-B guarded bridge; B, Otto Wolff 6-dial MW31; C, Rubicon 1081; D, Gray Instrument E-1005; E is EPIC portable bridge; F is Shallcross 638-R, a Wheatstone-Kelvin bridge.

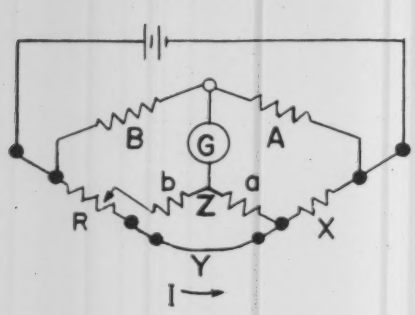


FIG. 9. KELVIN bridge principle.

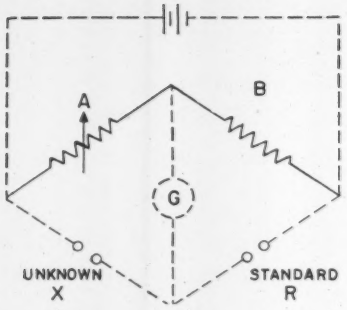


FIG. 11. IN direct-reading ratio set arm B is fixed; in universal ratio set both A and B can be varied.

The Kelvin bridge compares the unknown with a standard calibrated and variable resistance arm (arm R) as has been described. For very low resistance, arm R is usually a bar of manganin with a sliding contact. The Kelvin bridge uses the technique shown in Fig. 9 to remove this sliding-contact resistance from the balancing circuit.

Two additional arms (a and b) are introduced as shown. Effectively, if the ratio a/b is kept the same as the ratio A/B, then it can be shown that $X = R(A/B)$, which is the normal working equation of a Wheatstone bridge. Hence a and b in no way affect the bridge balance as long as $A/B = a/b$.

Note that the low resistances R and X are low-valued 4-terminal resistors (usually shunts) whose current and potential terminals are connected as shown. The connection between R and X is made by a special low-resistance yoke. Thus the only terminal that can cause emf trouble is the sliding contact on R—and this is not in the battery circuit at all because the battery current will flow through the low-resistance Y path rather than the higher resistance path a-b. Effectively, therefore, the bridge point Z is located on Y, but without touching it, and the troublesome contact on R is in series with resistors a and b so that its effect is small. Note that the ratios A/B and a/b must be equal for proper operation of a Kelvin bridge. Also, as large currents must be used, the ratings of all resistors used must be observed. Even with the large currents the IR drops are small, and a sensitive galvanometer must be used. As thermal emf's can cause trouble, battery polarity should be reversed and readings taken with both polarities.

Typical Kelvin bridges are shown in Fig. 10.

Fig. 10A shows the Gray Instrument Kelvin bridge E-1654. The low-resistance rheostat is at right; ratios are selected by switch at left.

Fig. 10B is the Otto Wolff Kelvin bridge Model MT4 with range for 10^{-6} ohm to 111,110 ohms. This unit can be used both as a Kelvin double bridge and a Wheatstone bridge.

Fig. 10C is the L&N 4300 Kelvin bridge. It comprises a 4320 Kelvin Bridge Ratio Box (top) plus a 4300 Adjustable Low-Resistance Standard Resistor (bottom) with sliding contact. Range is 10^{-8} to 1 ohm. This combination can be balanced to precision of $\pm 0.04\%$ above 5×10^{-5} ohm; ± 0.02 microhm below 5×10^{-5} ohm.

Fig. 10D is a Rubicon Model 1622 Kelvin bridge.

Fig. 10E is EPIC Kelvin bridge with range from 0.00005 to 2.1 ohms.

Other resistance-measuring techniques are used by the NBS to establish the absolute ohm, and precision comparisons of resistors are often performed by resistor manufacturers. But these are not common laboratory techniques, as are the Wheatstone and Kelvin techniques described.

Ratio Sets

The use of ratio boxes, or ratio sets, to measure resistance is becoming increasingly popular and important.

In the Wheatstone bridge the ratio arms provide ratios (A/B) in powers of 10, and the rheostat arm provides an adjustable resistor that is compared against the unknown. In the ratio set the instrument provides only the ratio arms, and the unknown is compared against an external standard resistor (Fig. 11).

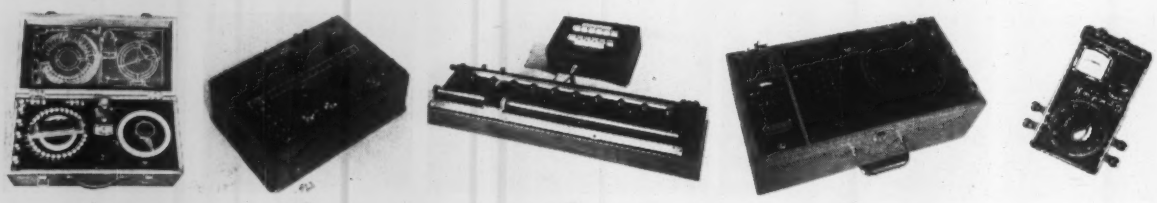


FIG. 10. KELVIN bridges. A is Gray Instrument E-1654; B is Otto Wolff Model MT4; C is L&N 4300; D is Rubicon 1622; E is EPIC model.

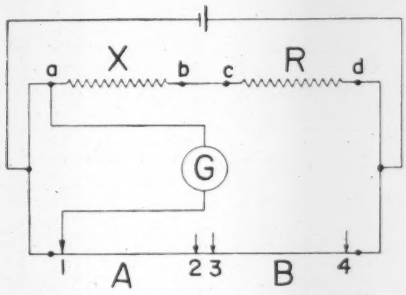


FIG. 12. USE of Universal ratio set for low resistance.

Note that in the Wheatstone bridge $X = R(A/B)$ and R is varied; whereas in the ratio set R is fixed (it is usually a standard or comparison resistor) and the ratio A/B is varied to effect a measurement.

Fig. 11 shows the principle elements of the ratio set. It provides arms A and B. An external detector and battery, in addition to the standard and unknown resistors, is all that is required to complete a Wheatstone-type circuit.

Direct-Reading Ratio Set

There are two types of ratio boxes—direct reading and universal. In the direct reading, arm B is fixed (usually at 100 ohms), and arm A is varied (usually from 99.44... to 100.55... ohms in increments of 0.001 or 0.0001 ohm). Note that the available arm reads directly in percent or parts per million of the standard resistor because $X = R(A/100)$ and A can be varied in increments of 0.0001 ohm, representing 1 ppm of the 100-ohm arm.

As arm B is fixed, and as standard resistors are available only in decade or decimal values of 1 ohm, the direct-reading ratio set can read only similar values; this instrument is used primarily for comparing resistors against standard resistors. To measure odd-value resistors, a Universal Ratio Set should be used.

Universal Ratio Set

In the Universal Ratio Set both arms A and B can be varied, permitting the measurement of odd-valued resistors because $X = RA/B$.

The technique shown in Fig. 12 permits the measurement of low-value resistors to parts-per-million accuracy. Let us consider the two arms A and B to be one slidewire, and let us connect the galvanometer to points a, b, c, and d in succession, balancing the bridge each time, giving the points 1, 2, 3 and 4. Arm A is thus the reading between points 1 and 2; arm B between 3 and 4. The unknown is thus $X = R(A/B)$, with automatic compensation for lead and contact resistance between X and R. This technique need be used only for resistances less than 10 ohms. Above this value the galvanometer can be connected directly to the junction between X and R, and to the junction between arms A and B (which are actually step switches, not a slidewire).

The Universal Ratio Set is also the best and simplest method for calibrating Wheatstone bridges and potentiometers.

Fig. 13 shows typical commercial ratio sets. Fig. 12A shows the Otto Wolff 4-dial Direct-Reading Ratio Set Model MVI with Auxiliary Unit Model HMV1, which switches leads without removing them from the terminals. Standard resistors (shown) can be compared to within 1 ppm or better.

Fig. 13B shows an L&N 4392 Wenner Ratio Box which permits comparisons of resistors to 4 ppm.

Fig. 13C is a Gray Instrument Ratio Box E-1055B.

Fig. 13D is a Rubicon Universal Ratio Set.

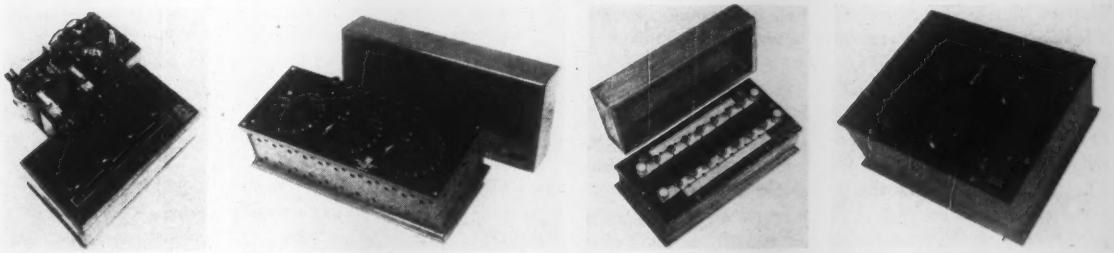
Special Bridges

Mention should be made of the many bridges that are designed for special-purpose resistive-type measurements, such as strain-gage and conductivity bridges. They are designed to accomodate resistive-type sensing elements, and calibrated in the appropriate units for the variable being measured. Strain-gage bridges have been discussed previously*; conductivity bridges will be discussed in the near future.

Acknowledgment

The helpful comments of A. R. Bechtel, Gray Instrument Company; E. Benson, Rubicon Instruments, M-H; J. B. Kelley of Physics Research Laboratories Inc.; R. G. Goettelman of Leeds & Northrup Co.; J. L. Thomas of the National Bureau of Standards; and M. Steinberg of Sensitive Research Instrument Corp. are gratefully acknowledged.

**Strain-Gage Instrumentation*, Aronson & Nelson, Instruments Publishing Co., $2.00.



A B C D

FIG. 13. RATIO SETS. A is Otto Wolff MVI with auxiliary HMV1 switch; B is L&N 4392 Wenner Ratio Box, C is Gray Instrument E-1655B; D is Rubicon set.

FIG. 1. TEST SETUP for measuring resistance of a 1' sample.

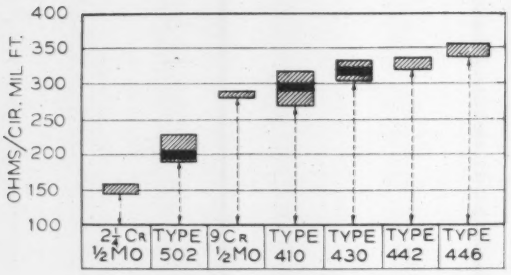


FIG. 2. RESISTIVITIES of martensitic and ferritic stainless steel alloys.

Wire Identification by Resistance

Resistivity of stainless-steel arc-welding rods and coated electrodes can be used for accurate identification of wire stock comprising many different alloys and wire diameter.

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The McKay Co.

RESISTIVITY MEASUREMENTS are a standard quality control test procedure at the York, Pa., plant of the McKay Company. Such measurements have been used for several years to supplement established quality control techniques.

The testing equipment consists of a source of direct current, a Leeds and Northrup Kelvin Bridge Ohmmeter, and a specimen holder (Fig. 1). The copper contacts are engaged firmly to provide one foot of test wire. The circuit is balanced using the Kelvin Bridge Ohmmeter and readings are converted to ohms per circular mil foot.

Results

The wide variety of alloys tested were subdivided into the following four major groups—(1) chromium stainless steels, (2) conventional chromium-nickel stainless steels, (3) high-nickel alloys, (4) specialized alloys—high-temperature material, corrosion resistant alloys, rapidly work hardening wires, and precipitation hardening metals.

The results for martensitic and ferritic stainless steel alloys are shown in Fig. 2. The height of the cross-hatched square represents the maximum spread of values obtained in all tests of the particular alloy. The solid bar within the rectangle indicates the resistivity level encountered most frequently. Resistivity of virtually all the martensitic and ferritic stainless steel wires tested is less than 350 ohms per circular mil foot. Resistivity increases sharply as the chromium content of the specimen increases from 2¼% to 12%. The net effect on resistivity of increasing the chromium content further to 28% is less marked.

Most conventional *chromium-nickel stainless steel wires* tested have a resistance of 400 to 500 ohms per circular mil foot. Type 330 wire has the highest resistance and Type 304 wire is the most conductive.

Resistance of the three *high-nickel alloys* tested in this manner varies widely. Commercially pure, grade-A nickel wire has a lower resistance than any other type tested. The addition of approximately 20% of chromium or of approximately 15% of chromium and 25% of iron to the high nickel matrix markedly increases the resistance.

The comparative resistance of *specialized alloys* varies widely. As a group, Hastelloy materials have the highest resistivity of any materials checked during this investigation.

Resistivity measurements can be an accurate, rapid quality control technique for identifying or sorting highly-alloyed welding wire. Best results are obtained when there is a minimum difference of 50 ohms per circular mil foot in the resistivity level of the alloys under consideration. In specific cases, successful separations have been made where the margin of difference in resistivity was appreciably less than this value.

Acknowledgement

The author expresses his appreciation to the McKay Company for permission to publish this data, and to Mr. H. F. Reid, Manager of the Technical Service Division, for his assistance.

Voltage References

The standard cell is the basic working reference-voltage standard, but new secondary-standard voltage references with accuracy of 0.01% offer flexibility in calibration of instruments, measurement of voltages, and precise attenuation of voltage.

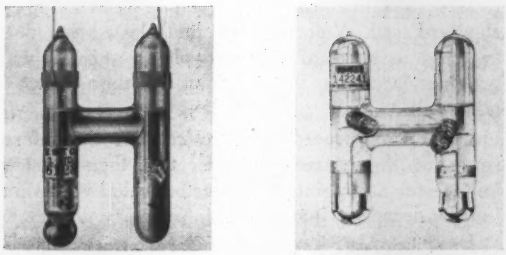


FIG. 1. CADMIUM saturated standard cell (left) is best known reference of emf, with reproducibility of 1 or 2 ppm; unsaturated cell (right) is common working standard.

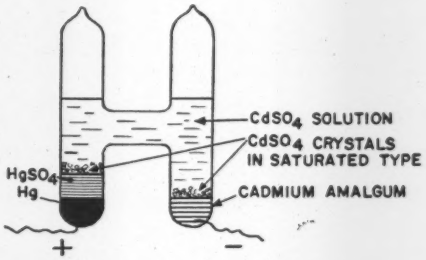


FIG. 2. ELEMENTS of a standard cell. Most cells made today also have a little H_2SO_4 added to the electrolyte.

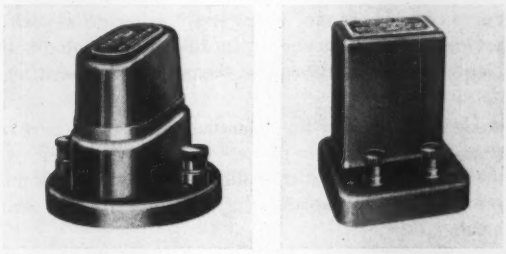


FIG. 3. TYPICAL mounted unsaturated standard cells. A shows Weston model; B shows Eppley model.

THE WESTON CADMIUM (saturated) standard cell (Fig. 1) has been the reference or working standard of emf ever since the London International Electrical Congress adopted it in 1908 (with a value of 1.0184 international volts, changed to 1.018636 volts in 1948). The more portable unsaturated form of standard cell (Fig. 3) is the most common precision voltage reference, with the saturated type used only for those applications requiring the utmost precision. It is individually calibrated against the saturated standard cell because each unsaturated cell has a slightly different emf. The decrease in voltage of the unsaturated cell has been reported as 0.003% per year, and hence should be rechecked every year or two.

The saturated (normal) standard cell has a temperature coefficient of -40 μv/C°; the unsaturated has a maximum coefficient of -10 μv/C°.

The following precautions *must* be observed when using a standard cell:

1. Currents in excess of 100 microamperes never must be drawn from the cell. This means that the cell never must be short-circuited, nor should a voltmeter be used to measure the voltage of the cell (as the internal resistance is between 100 and 500 ohms, a voltmeter reading is meaningless). The cell emf should be measured by potentiometer.

2. The cell temperature should always be between 4 and 40°C and all parts of the cell should be at the same temperature.

3. The emf should be redetermined and checked every year by potentiometer.

Saturated cells are mounted in groups of 3 to 6 because the only way to detect a variation in a cell emf is by comparison with other cells. A comparison of two cells would detect a variation, but would not tell which cell varied; thus 3 is the smallest practical group. Five or six cells is a good compromise between cost and accuracy. Some laboratories use three groups of three cells each, keeping one in a controlled home environment, using the other two for

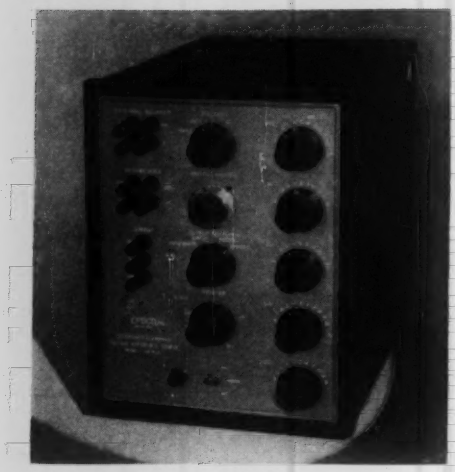


FIG. 4. EPSCO Model VR-607 secondary standard voltage reference source has accuracy of 0.01%, output resistance of 1 ohm max, to currents of 5 ma.

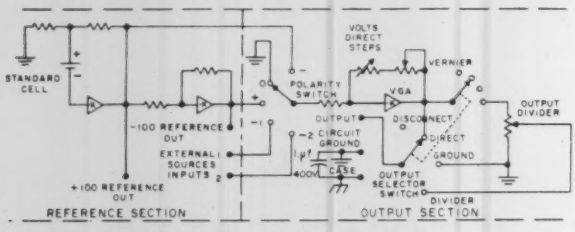


FIG. 5. SCHEMATIC of VR-607 shows standard-cell reference and chopper-stabilized operational amplifiers. Output is varied by changing the gain of the variable-gain amplifier (VGA) via its feedback.

comparison with other standard groups, such as the NBS group.

Unsaturated cells can be mounted in metal or bakelite cases (Fig. 3). These are usually lined with copper for thermal shielding and felt for mechanical and thermal protection.

The most important measurement associated with a standard cell is measurement of its emf. Such measurement is almost always done by comparison with other cells. Special standard-cell potentiometers (standard-cell comparators) are available. In these, the reference cell and the cell to be measured are connected in opposition, with the small difference in emf being itself opposed by a measureable drop across a resistance. As the difference in emf is usually less than 10 μv, even a 1% error in this measurement means a voltage of 0.1 μv, or 1 part in 10^7 of the 1-volt measurement.

The flexibility and applicability of the standard cell has been increased enormously by the appearance of *secondary-standard voltage-reference sources* comprising a standard cell and highly stable operational or chopper amplifiers, so that the source provides any desired voltage at near-standard-cell accuracy. The following are examples of such sources.

Epsco Model VR-607

The Epsco Model VR-607 (Fig. 4) is an accurate and stable reference source of voltage which can be used for (1) generation of a precision voltage for calibrating instruments, such as voltmeters and oscilloscopes, (2) measurement of external voltages, and (3) attenuation of external voltages. The principle is shown in Fig. 5.

Calibration applications are the most common. The wide range of the reference source permits calibration of a voltmeter with a full-scale range of 10 millivolts as accurately as a voltmeter with a full-scale range of 100 volts; further, the accuracy equals that obtainable by potentiometer technique.

Output voltages can be selected either by decade decimal selectors or by binary-coded toggle switches, plus divider and vernier controls for further resolution. For example the output voltage ranges of the decimal and binary models of the VR-607 is decimal: $\pm$111.112 v dc; binary: $\pm$100.0008 v dc.

Voltages accurate to 0.01% can be selected down to zero volts, not just to the 1-volt value of the integral standard cell. Voltages can be selected by decade switches in steps of 1.0 millivolt; a vernier control provides accurate interpolation to the nearest 0.1 microvolt.

Calibration procedure is to connect the reference source to the instrument under test, then generate a voltage for any point on the meter scale by manipulating the decade switches.

Measurement of external voltages requires use of a null meter. One model (VR-608) has a null meter on the front panel for these applications; an external null meter can be connected to the output terminals of other models (VR-607 or VR-607B). The exact value of the external voltage is read simply by noting the settings of the various decade switches.

Using the null technique to calibrate or adjust an external device involves the same procedure. Typical applications include the calibration of transducers such as thermocouples, strain gages, etc. The reference source frequently has been used as the central calibrator of wind-tunnel instrumentation systems, structural test systems, data acquisition systems, and aircraft and missile checkout systems.

The final category involves the use of the reference source as a *low-impedance attenuator** of extremely accurate larger voltages. For example, an application may require the accurate 100-volt full-scale output of an analog computer to drive a device with a 10-volt input full-scale range. Applying the external voltage source to the unit shown in Fig. 4, any attenuation factor can be achieved by the appropriate setting of the decade switches.

Used in this way the reference unit can be part of a closed-loop automatic process control system, effecting the required link between the analog computer control information source and the control actuation equipment.

*The ouput impedance of the reference source is 5 milliohms (0.005 ohm) in series with 5 millihenries shunted by 50 ohms.

Kin Tel Model 301

Fig. 6 shows the Kin Tel Model 301 d-c voltage standard and null voltmeter. It uses a chopper circuit to compare the output against an internal standard cell, providing d-c voltages to an accuracy 0.02%.

Output voltage of 1 to 501 volts can be set directly on the calibrated dials, and up to 20 ma currents can be provided. Output hum and noise is less than 100 μv rms. Line and load regulation is 0.002%.

As a d-c standard, the calibrated dials provide any desired voltage within the range, and any external voltage can be measured simply by setting the dials to null out the reading, the voltage being read directly from the dials.

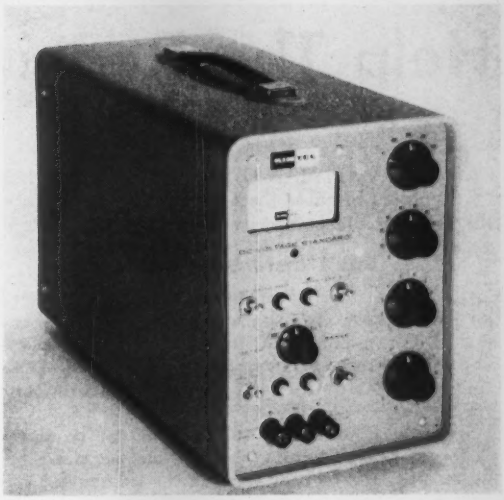


FIG. 6. KIN TEL Model 301 is precision voltage standard with calibrated null voltmeter.

NLS Model 50

Fig. 7 shows the Model 50 comparator of Non-Linear Systems, Inc. It contains two internal secondary-standard voltage references. These voltage references are Zener diodes mounted in an oven to control temperature to ½°C and therefore reduce temperature drift to 0.001% up to 175° ambient temperature. This stability is said to be better than the stability of standard cells when the standard cells are subjected to wide temperature ranges. It is for this reason that NLS is switching over to Zener-diode-type secondary-standard voltage supplies in digital voltmeters, eliminating the use of standard cells.

The NLS new Model V35 digital voltmeter also can find application in the precision measurements field. Its digital logic permits a resolution of 0.001% over the entire operating range.

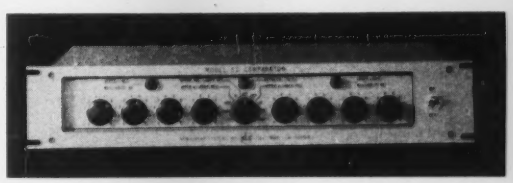


FIG. 7. NLS Model 50 voltage comparator has two internal secondary-standard voltage references, using Zener diodes.

Sensitive Research Instrument Corporation

Sensitive Research offers a voltage standard (Fig. 8) that provides 1.0185 volts and 1.0000 volt to a certified accuracy of 0.01%. Special units are available for any specified voltage to 7.5 volts, 0.5 ma.

The supply can be considered a perfect voltage source with internal resistance of 2000 ohms. Hence maximum short-circuit current is 0.5 ma. The output is fully accurate only into an infinite-impedance load (as in a balanced potentiometer circuit), but it can be operated into any impedance, including a short circuit, without harm. It cannot be damaged by overload.

Basic applications include use wherever an unsaturated laboratory standard cell is used, with the advantage of (1) improved stability or drift characteristics, (2) better temperature coefficient, (3) freedom from damage due to overload or rough handling.

Other applications are found in precise comparators or voltmeters. For example, when used with the "Incremeter" differential galvanometer, the reference-voltage unit passes a precise current through one coil of the differential instrument; an unknown current in the other coil can be measured to an accuracy of 0.05%. By adding series resistors, the unit becomes a voltmeter. By these same technique, suppressed-zero voltmeters and ammeters can be made with an accuracy of 0.05%.

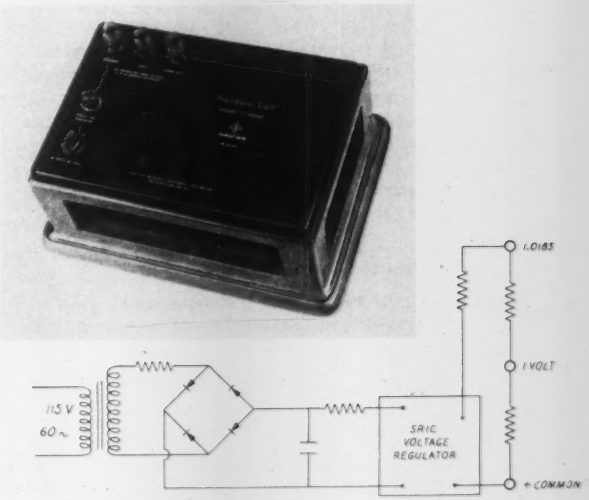


FIG. 8. SENSITIVE RESEARCH Model STV "Standard Volt" supplies 1.0185 and 1.0000 volts to 0.01% accuracy. Voltage regulator uses selected and aged Zener diodes.

Help The Repair Shop

FRED LINGEL
General Electric
Instrument Department
West Lynn, Mass.

A SERVICE MAN GIVES THIS LIST of helpful hints to guide the user into the good graces of the Test Equipment Service Shop.

Don't Disturb Components

1. Try not to rub off all traces of special numbers on parts. These are usually the defective ones!
2. Don't unplug and change resistors, capacitors, and other components which can be removed or moved to a different position. If you must, note it on the service tag.
3. If there are several tubes which can be moved to different sockets, number the tube and its socket before unplugging the tube or sending the unit in for repair. Selected tubes are often used in test equipment and you never can tell when there may be a different filament supply, or a series filament circuit, or special low interelectrode capacity, or balanced pairs.
4. Always replace parts you may have removed.
5. When returning a piece of test equipment for servicing, always return accessories such as plugs, adaptors, line connectors, etc.
6. If you must send your unit out of the plant for repair, be sure you get full packing and shipping instructions from the manufacturer first. Oftentimes a recommended local authorized service shop will give you better service than the main plant.

Don't Readjust Your Instrument

1. Under no condition send the test equipment in for repair after you have turned a sealed potentiometer or a concealed adjustment just for so. If you must do this, make a note on the repair tag! The little screws on the tops of filters, I-F cans, etc., are not to be "tightened down" even on test equipment.
2. You can trust your test equipment if it is used properly, even though the "pet" unit you have haywired together is your pride and joy. Don't readjust your commercial test equipment to match your haywire. It may get you by for now, but it will surely lead to a day of reckoning later.
3. If your test equipment shows the unit under test to be defective, don't attempt to modify the test equipment. Do not smooth out that jump in the curve by changing adjustments on your test equipment either; get at the real cause instead.

Don't Change the Design

1. Don't try to repair the test equipment yourself unless you are skilled in the unit you're repairing. Also be cautious about the suggestions of the fellows near you as to what is wrong—they may know even less than you! There is nothing like the "expert" who wouldn't dare touch his own equipment, but who is more than willing to tell you how to repair your unit!
2. If you must make minor repairs, leave some clue of your deed. While the shop has lots of parts, and schematics for different makes and models, a guessing game is not their favorite sport.
3. Inform the Repair Department or Service Station in writing, with your signature and date, of special changes you want in the equipment.

Don't be Secretive about Defects

1. Don't just write the word "repair" on the tag. Tell the repair man with as much detail as possible.
2. When the newly calibrated "rush-return" test equipment is back with you after several days of heckling the repair man, see if it has been repaired and use it immediately or else have a good reason why not.
3. Don't follow up too fast on a service job. Allow three days to a week to get the equipment into his shop before you start phoning him about it.
4. Don't build up your own personal library of the manufacturer's instruction books and wiring diagrams, especially if your unit is one of the only ten specials manufactured. Send the instruction book for your particular tester along with it. It is one of the nice ways to show the service man you are on his side.

Don't Mistreat your Test Instruments

1. Don't use test equipment as a holder for soldering irons, coffee cups, etc. Plastic instrument covers discolor to very interesting patterns, but try not to encourage this type of art.
2. Don't cover vents and cooling fins, especially on equipment with a blower system. Even though the blower may cause a bothersome draft and hot equipment keeps moisture from forming inside the case, (it says in small print), it is not good practice. Don't cover the vents when the unit is left on over-night; this may result in your checking the performance of the sprinkler system instead!
3. Always place test equipment well back on the bench even though you may have to bend over to look at it. Prop it on the edge of a shelf or test bench and the slightest jar on a test lead will set science back another two weeks!

Don't Use under Abnormal Conditions

1. Always use the test equipment on rated line voltage. Don't use an outlet to which you have attached a larger blower, heavy soldering iron, soldering pot, heater, coffee maker, etc. Lowering the line voltage is not the way to make the test equipment last longer! If the line voltage is low, you can look for inconsistent operation, off calibration, etc. Abnormally high line voltage can cause just as much trouble, especially when you plug it into a 220 line instead of 110.
2. Always operate the test equipment in its normal position. Don't prop it 45° to provide better readability from where you happen to be sitting. The manufacturer's position specification for pointer balance, heat convection flow, gravity trip-out, etc., are in for a purpose; adhere to them.

Much of this information was taken from the "files" of the Material and Processes Lab. Service Group in Building 3 at Electronics Park. The author wishes to acknowledge the efforts of Earl Arnold, one of the supervisors in this group, who sparked the work for this article. (Note to instrument men: If I've missed your pet peeve against test equipment users, please send it to me.—F.L.)

CONTINUING THE SERIES
ON ELECTRICAL MEASUREMENTS

Potentiometers

The names Feussner-Brooks, Diesselhorst-Hausrath and Kelvin (Cascade) potentiometers identify advanced potentiometers featuring high accuracy and wide range, and with special historical significance.

JAMES B. KELLEY
Physics Research Laboratories, Inc.

HANS H. MAROLD
Otto Wolff Präzisions-Widerstände

THE INSTRUMENT POTENTIOMETER is probably the oldest of the precision current and voltage measuring devices. It dates to at least 1841, when it was first described by Poggendorff and called a "Kompensationsapparat," a name it still bears in Europe. Many changes have been made since Poggendorff's time, and the names we are most apt to associate with d-c potentiometer design today are Brooks, Wenner, Diesselhorst, Hausrath, Feussner, Lindeck and Rothe, among others. The last five named men are all German. Another name which might not be so readily associated with potentiometers in this country is Lord Kelvin. Using the Varley type of resistance cascading, the Kelvin potentiometer is similar in basic concept to the Kelvin-Varley type of voltage divider.

The discussion of potentiometers which follows is devoted to several European types (especially those made by Otto Wolff), which were not included in previous discussions. Two features characterize these potentiometers: (1) high accuracy—$\pm 0.01\%$ or higher and (2) the exclusion of slidewires from the designs. A potentiometer should be chosen for the job it must do. Hence, emphasis will always be placed on where the particular potentiometer will perform *best*—but this should not be interpreted to mean that it will not perform well in other applications.

The three types discussed are: (1) Feussner-Brooks, a high-internal-resistance potentiometer, which offers measuring accuracies of the order of $\pm 0.005\%$ from 100 millivolts upward and is a general-purpose instrument for calibration or standardizing work; (2) the Diesselhorst-Hausrath potentiometer, which is a low-internal-resistance instrument whose accuracies may run as high as $\pm 0.003\%$ or higher and is suited best to work where differences of a few microvolts must be determined with great precision; (3) the Cascade, or Kelvin, potentiometer which has a moderate internal resistance and is widely used where most measurements will be in the millivolt or tenths of millivolt range. Measuring accuracy is of the order of $\pm 0.01\%$ or higher. All potentiometers can be used above 1 volt with suitable volt boxes, and will only be limited in range by the volt boxes available. One word of caution: Whenever instruments are being used in these accuracy categories, the operator technique may become the most important factor in the measurement.

Feussner-Brooks Potentiometers

The Feussner potentiometer was first described in 1890 and was built by Otto Wolff. Since that time Otto Wolff has continued to make the Feussner type of potentiometer—now known as the Feussner-Brooks. The Brooks addition to the design was made by placing the standard-cell rheostat in the potentiometer itself instead of having it connected as a separate accessory. Both Feussner and Wolff agreed this was advantageous. Wolff still refers to this type of standard-cell rheostat as a "Brooks Decade." Fig. 1 shows a modern 6-dial version of the more familiar 5-dial unit; Fig. 2 shows the circuit diagram for a 5-dial Feussner-Brooks which has two auxiliary current ranges.

The Feussner-Brooks potentiometer is a *high-resistance* instrument. The internal resistance is 10,000 ohms per volt. A standard unit has a total internal resistance of 20,000 ohms. Hence it will withstand a great deal of hard usage, but will, on the other hand, be subject to thermal effects. Its accuracy is high and its range wide—Wolff units go as low as 1 microvolt. The advantage which the two standardizing currents give to the instrument is that the instrument is shifted to a lower range without adding another dial. Thus a 5-dial unit with two standardizing currents has a range of 10^{-5} to 2.0 volts, or 10^{-6} to 0.2 volt.

As an example of the kind of accuracy which might be expected from a Feussner-Brooks potentiometer, the following information is taken from a certificate issued by a standards laboratory which tested a production

model that was to be used in a laboratory of a European university:

1. The maximum error on the first dial was 1 part in 20,000;
2. The maximum error in the second dial was 1 part in 20,000;
3. No errors were shown in the third, fourth and fifth dials.
4. With all dials set at zero, the "zero voltage" amounted to 0.2 μv.

These readings were all taken in millivolts on a 5-dial Feussner-Brooks which bore a Wolff serial number indicating a 1956 date of manufacture.

Other tests conducted by other laboratories in other countries indicate that these figures are typical. Other data indicates that an error of $\pm 0.005\%$ in the first and second dial is the maximum to be expected. Usually the remaining dials exhibit no significant errors, but thermals may introduce errors. The Feussner-Brooks potentiometer will serve its user best when it is used from 0.1 volt and upward. Below 0.1 volt, the accuracy is no better than $\pm 0.01\%$ and will fall off to perhaps $\pm 0.02\%$ at 0.0001 volt and below. However corrections can be made to overcome this increase in error, but if a majority of measurements are to be made in the low or fractional millivolt range, choose a Kelvin type of potentiometer. Above 0.1 volt, the laboratory man can expect accuracies of at least $\pm 0.005\%$ and possibly higher. With the addition of a suitable volt box and shunt box, the Feussner-Brooks potentiometer will solve all direct-current instrument and emf calibration problems for voltages as high as 1500 volts and currents as high as 750 amperes. Both of these limits may be raised if suitable volt boxes and shunt boxes are available.

Diesselhorst-Hausrath Potentiometers

The Diesselhorst potentiometer was first designed in 1908 and was based on initial studies made by Hausrath. The first Diesselhorst-Hausrath potentiometer was made by Otto Wolff in 1908, and since that time the Wolff firm has continued to be the principal manufacturer of this type of potentiometer. In 1957 the Wolff firm, together with Professor Diesselhorst, revised and redesigned the potentiometer. It was also at that time that Professor Diesselhorst requested that Hausrath's name be added to the potentiometer in view of Hausrath's early and vital researches in the field of low-thermal-emf potentiometers.

The Diesselhorst-Hausrath underwent still another change in this same period. Dr. Heinz Eicke of the PTB-Berlin (Physikalische-Technische Bundesanstalt-Berlin) made some additional changes in the Diesselhorst-Hausrath design. Thus, although this potentiometer is one of the oldest, it is, in some respects, one of the newest.

The Diesselhorst-Hausrath is a *low-resistance* potentiometer; the total resistance is approximately 14.5 ohms. This is true of both the original designs of Diesselhorst and also the later redesigns made by Wolff and Diesselhorst.

The Eicke version of the Diesselhorst-Hausrath potentiometer, known as Model KDE 7 (Fig. 3) has a total resistance across the B terminals of 20 ohms and a total resistance across the unknown voltage terminals of 24.4 ohms. One of the important advantages of this model is that all four ranges may be changed without readjusting the auxiliary current. The ranges are 10^{-8} to 12.5 volts (KDE 6); 10^{-8} to 1.1 volts (KDE 7). The KDE 8 (6-dial version of KDE 7) goes one step lower. The measuring accuracy of the KDE 6 and KDE 8 is of the order of $\pm 0.01\%$. On the lower ranges this will be affected somewhat by the effects of thermals—thermal errors being of the order of 0.1μv. For the KDE 7, the measuring accuracy is of the order of $\pm 0.003\%$ and thermal errors are of the order of 0.01μv.

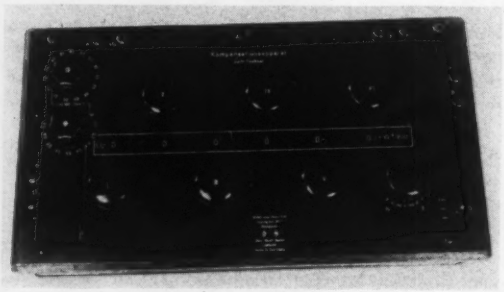
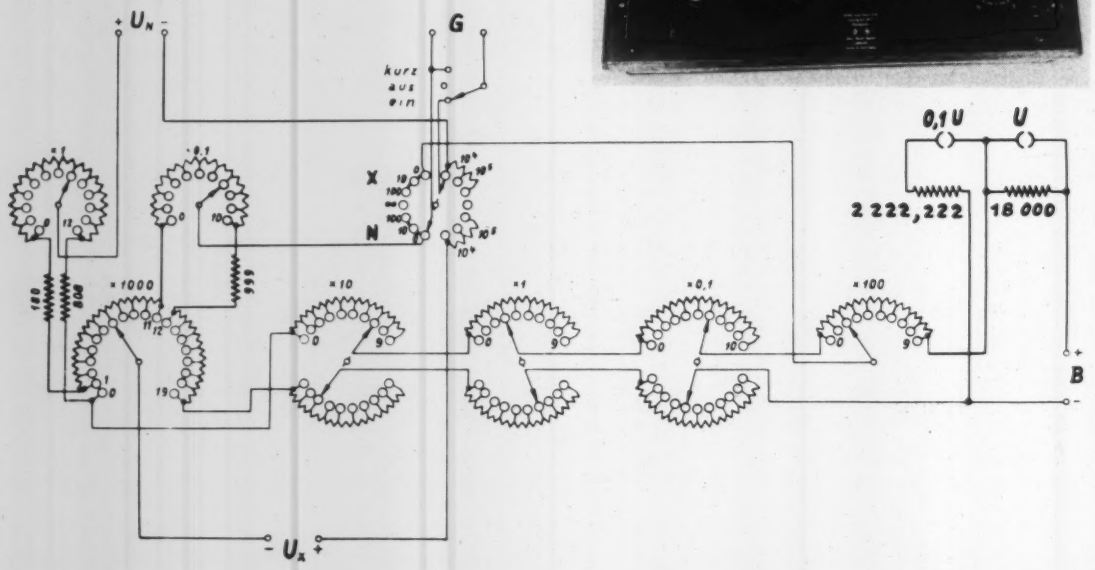


FIG. 1. FEUSSNER-BROOKS Model KF5 potentiometer.

FIG. 2. FEUSSNER-BROOKS Model KF 41 potentiometer, schematic.



The Diesselhorst-Hausrath potentiometer is the most versatile of all potentiometers discussed here. It can be used directly without modification for the following:

1. Calibration of resistance thermometers;
2. Calibration of thermocouples (work which the authors observed it doing on a recent visit to PTB-Berlin);
3. Calibration of a voltage source;
4. Calibration of an ammeter or voltmeter;
5. Calibration of a standard resistor.

With regard to resistance thermometers it will handle the range up to 1000°C without difficulty, and it is widely used in this work. The PTB finds the Diesselhorst-Hausrath potentiometer especially useful for calibrating thermocouples and use it almost exclusively for this purpose. However, a smaller laboratory could use it for anything for which an ordinary potentiometer would be used. With the aid of shunt and volt boxes, its range can be extended into the practical instrument calibration region.

Kelvin Potentiometers

The Kelvin (or, as they are known in Europe, Kaskaden-Kompensator) potentiometers are intermediate between the Feussner-Brooks and the Diesselhorst-Hausrath potentiometers. The KKE 12, for example, has a total resistance of approximately 1000 ohms. The range for measurements is 10^{-6} to 1.1 volts (up to 600 volts with built-in voltage divider) the measuring accuracy is of the order of $\pm 0.01\%$ and the recommended range for use is 10^{-4} volt to 1500 volts (with volt box).

Conclusion

In summary it can be said that:

1. The *Feussner-Brooks* potentiometer type has a high internal resistance and is most commonly used where ease of operation together with long-term reliability are needed for moderate and high voltage measurements.
2. The *cascade* (*Kelvin*) type potentiometer has intermediate resistance and is recommended where measurements will be largely above 100 μv and where high accuracy must be available.
3. The *Diesselhorst-Hausrath* type potentiometer has a low internal resistance and is specially suited for the thermocouple and resistance thermometer measurements, but is also recommended for general use including low voltage measurements, where its low thermal losses make it most desirable.

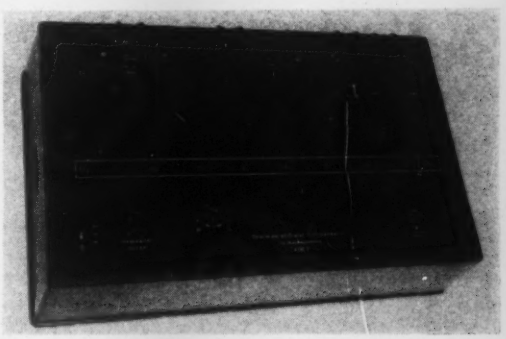
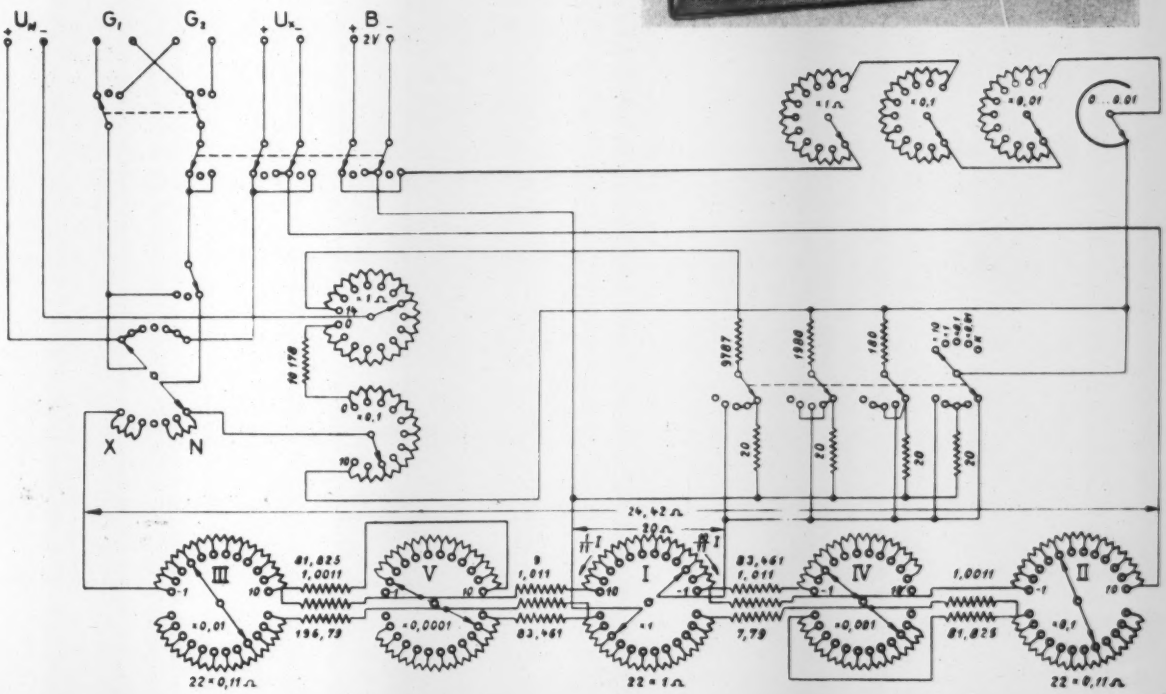


FIG. 3. DIESSELHORST-HAUSRATH Model KDE 7 potentiometer.

FIG. 4. DIESSELHORST-HAUSRATH Model KDE 7, schematic (first-time published in USA).



Proper Use of
INSTRUMENT ACCESSORIES

Accessories for basic electrical instruments include shunts, multipliers, current transformers and potential transformers. Here are basic application factors, including essential precautions.

JOHN H. MILLER
Weston Instruments Div.*
Daystrom, Inc.

A WIDE RANGE of instrument accessories are available for extending the range of basic instruments. These include shunts for high direct-current measurements, series resistors or multipliers for high potential, and instrument (current and potential) transformers for high alternating-current values.

Shunts

The maximum current which can be passed through the moving coil and springs of a typical d-c instrument is in the order of 0.03 ampere; for higher ranges the bulk of the current is passed through a parallel resistance or *shunt.* Up to about 40 amperes these shunts may be internal, mounted in the instruments. For higher ratings an external shunt (a carefully adjusted four-terminal resistance) is used. Such shunts are rated at the current flow which will produce at their potential terminals the now-standard value of 50 millivolts. They are for use with an instrument adjusted to give full-scale deflection when 50 millivolts is applied to the far ends of its calibrated connecting leads. A typical shunt is shown in Fig. 1.

The shunt selected should have a rating somewhat higher than the maximum value of direct current to be expected and should be connected into the main circuit with adequately large conductors. This is particularly important for shunt ratings over 200 amperes because the heat produced in a shunt (50 watts per 1000 amperes) should be dissipated through its terminal blocks to the connected cable or bus bar. A high-current shunt would burn up if the heat could not get out through its connecting cables. Cables and bus bars should be bolted tight to avoid losses at the connections, as well as to allow for good heat flow.

Multipliers or Series Resistors

Voltmeters, both d-c and a-c, as well as wattmeters are usually limited to 300 volts for the top range, although some are made occasionally with internal resistance for as high as 750 volts. This limitation is imposed by the heating of power dissipation through the resistors within the instrument. For voltages higher than the self-contained rating, additional series resistors, commonly called *multipliers,* are connected in series with the instrument. These are usually adjusted for the specific instrument with which they are to be used, and serve simply to extend the voltage range. As an example, a wattmeter with a top rating of 300 volts may have an internal voltage circuit resistance of 9000 ohms. If we connect in series a 2-to-1 multiplier, also having a resistance of 9000 ohms, we can use the instrument up to 600 volts, multiplying the watt indication by 2.

A typical multiplier is shown in Fig. 2.

*Mr. Miller is consultant to Weston, of which he is a retired vice-president and chief engineer.

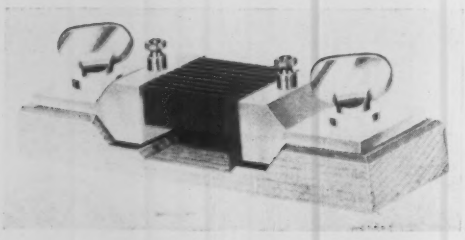


Fig. 1. Shunt

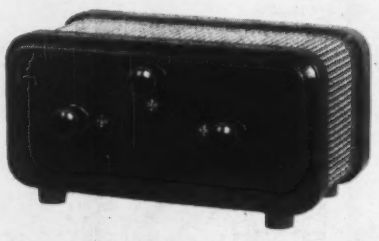


Fig. 2. Multiplier box.

Current Transformers

Instrument transformers (current and potential) extend the range of a-c instruments in the same way as shunts and multipliers extend the range of d-c instruments. The current transformer is a most valuable tool for measuring alternating current of more than 5 amperes, or above the range for self-contained shunts. Modern magnetic materials have made it possible to produce current transformers of such high accuracy that no correction for ratio or phase angle need be applied generally. Fig. 3 shows a typical current transformer and a schematic; actually each winding is spread completely around the toroidal core. In the form shown, primary currents of 100, 50, 20 or 10 amperes produce 5 amps in the secondary when connected to an ammeter or a wattmeter. For higher ranges, the primary conductor can be threaded through the window opening for 1, 2 or 4 turns to give the 5-ampere secondary value for 800, 400 or 200 amperes primary current, respectively, as shown in Fig. 3C.

For wattmeter measurements at high accuracy, formulae are available for applying phase-angle correction to the wattmeter readings in terms of the specific transformer phase angle and the instrument phase angle, if any.

Precautions must be observed when using a current transformer: **In using a current transformer it is imperative that the secondary circuit be closed.** If the secondary circuit is open, then the entire primary current, driven by the total available voltage, becomes magnetizing current. The core saturates, and when the current reverses at each alternation the flux collapses and builds up in the opposite direction. This flux build-up is so rapid that very high voltages are induced in the secondary, which may puncture the insulation and, if touched, be dangerous. If operated with the secondary open the transformer iron itself may become magnetized and give erroneous readings. Many portable current transformers are equipped with a secondary short-circuit switch, and this switch should be kept closed until the secondary circuit is complete. **Always arrange a closed secondary circuit in a current transformer before applying current to the primary.**

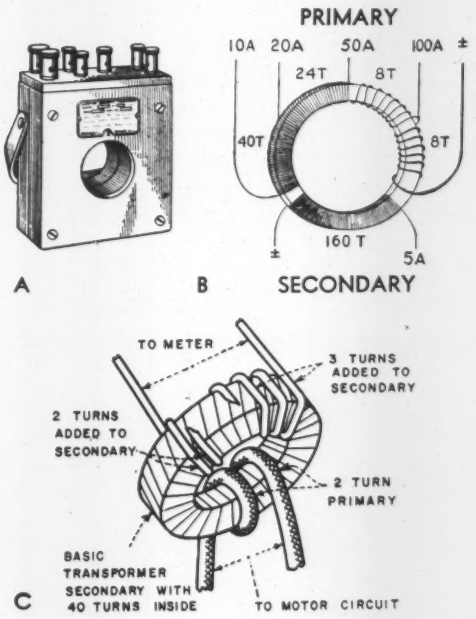


Fig. 3. A. Typical current transformer. B. Ranges depend on turns ratio. C. Higher range can be achieved by threading primary through toroid.

Potential Transformers

When measurements over 600 volts must be made it is customary to use *potential transformers* between the high-voltage line and the instruments. Such transformers (Fig. 4) have a standard secondary rating at 115 volts nominal, 150 volts maximum. For example, the ratio is usually expressed 2300/115 or 20/1.

In using potential transformers the secondary should never be short circuited, and may be left open without hazard. It is good practice to connect the secondary to the instrument potential system, usually the 150-volt range, before applying the primary potential. For the sake of safety to both the operator and the instruments, a potential transformer secondary circuit should be grounded at one point. Current transformers generally also will be used and it is customary to tie one side of both the potential transformer secondary and the current transformer secondary together and to ground.

Potential transformers, generally speaking, are not quite as perfect as current transformers; their ratio errors should be considered. Their phase angle also should be considered when used for measuring power.

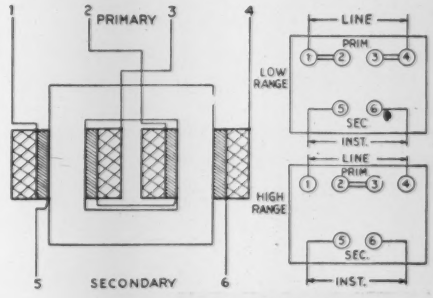


Fig. 4. Potential transformer with two primary coils and one secondary. Primaries can be arranged in parallel or series to give a range of 2:1.

Precise Measurement of Voltage, Current, Power and Energy by

INDUCTRONIC

This product resolver can be used for the measurement of volts, amperes, watts, and watthours (when used with a precision integrator). It offers 0.1% accuracy over a wide power and frequency range and povides a d-c output which can be used for control.

THE INDUCTRONIC ELECTRODYNAMOMETER was developed to produce an output current accurately related to the *product* of two input currents. The capabilities also include the measurement of voltage, current and power at 0.1% rated accuracy for dc or ac to 2500 cps. Transfer error between dc and ac is less than 0.04%, readability and resolution better than 0.02%. Response is fast and power loss is less than that of a conventional dynamometer. These features have been accomplished by combining an electrodynamometer and a permanent-magnet moving-coil mechanism.

This product resolver consists of a dynamometer mechanism and a permanent-magnet moving-coil mechanism with their moving coils both mounted on a common shaft. The torque produced by the dynamometer element is directly proportional to the in-phase product of the input currents to the fixed and moving dynamometer coils. The torque of the dynamometer element is automatically balanced by a current fed into the d-c moving coil from a d-c amplifier to produce a counter torque which keeps the system in balance (Fig. 2). The output direct current varies from 0 to 1 ma. It can be measured by a d-c indicating instrument, precision potentiometer, digital voltmeter, recorder, etc. It also can be used for control purposes.

The d-c magnetic structure has powdered-iron inserts and solid-iron pole pieces and core. The permanent magnet produces a steady flux linking the moving coil. A 200-kc field also is produced in the powdered iron inserts by field coils; the excitation for the 200-kc induction field is supplied by an oscillator in the amplifier.

With no current in the dynamometer coils the d-c moving coil does not link the 200-kc flux. As current is applied to the dynamometer coils, a torque is produced causing the moving element to turn. The d-c moving coil then links the 200-kc flux and produces a signal which is amplified, rectified, measured, and fed back as a direct current to the d-c moving coil to produce a torque exactly equal to the dynamometer torque.

Accuracy

The accuracy of indication depends on the accuracy and readability of the output instrument. For the most precise measurements the ouput current is passed through a precision resistor, and the voltage drop is measured by a precision potentiometer. The direct-current output is 1 ma at rated input and the output resistance can be any value up to 5000 ohms. This provides ample power for accurate measurement and readability.

A typical wattmeter was tested at the National Bureau of Standards to determine the difference between indications on alternating current and reversed direct current. The difference was undetectable at 60 cps, 0.03% high at 400 cps, 0.01% high at 800 cps and 0.04% low at 1600 cps. The current circuit defect angle has been measured and is approximately 7 minutes at 2500 cps, decreasing to a negligible value at 60 cps.

Use as a Voltmeter

A series resistance is used with inputs A and B to indicate volts. The voltmeter uses moving and field coils rated at 50 ma for a multirange instrument of 300/150/75 volts. The series resistance consists of mica sheets wound with low-temperature-coefficient

Abstracted in part from AIEE paper 59-165.

ELECTRODYNAMOMETER

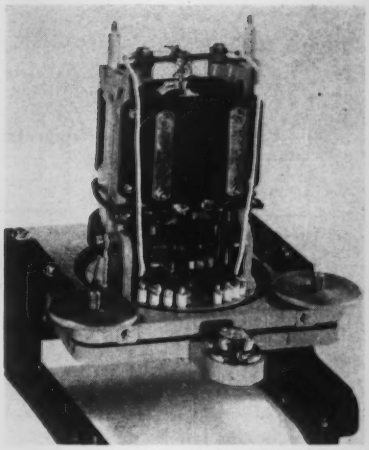


FIG. 1. ELECTRODYNAMOMETER unit with cover removed.

R. F. ESTOPPEY
Weston Instruments
Div. of Daystrom Inc.

resistance wire in a manner to be practically non-inductive and capable of maximum heat dissipation. The direct-current output is proportional to the input voltage *squared*.

Where required, frequency compensation is added by shunting the 75-volt range series resistance with a capacitor. Compensation is practically flat to 2500 cps due to the low ratio of reactance in the potential circuit. Calculations for the 75-volt range show $X_L/R = 0.25$ and $r/R = 0.95$ at 2500 cycles. The maximum frequency error determined is less than 0.01%.

This compensation is also very exact over the entire voltage range because the inductance in the potential circuit remains constant, and the Inductronic Voltmeter accuracy is better than 0.1% from direct current to at least 2500 cps.

Use as Ammeter

To measure 15 to 150 milliamperes, the moving and field coils are connected in series. Like the voltmeter, the d-c output varies as the *square* of the input current. If desired, the moving and field coils can be brought out to separate terminals and the instrument then can be used as a product resolver or current product meter.

Current ranges to 1 ampere are made possible by using a shunt across the moving coil. In order to keep the frequency and temperature errors to a low value, it is necessary to add resistance in series with the moving coil and shunt the combination. This requires approximately 5 volts across the shunt and makes ranges above 1 ampere impractical, except by use of a current transformer.

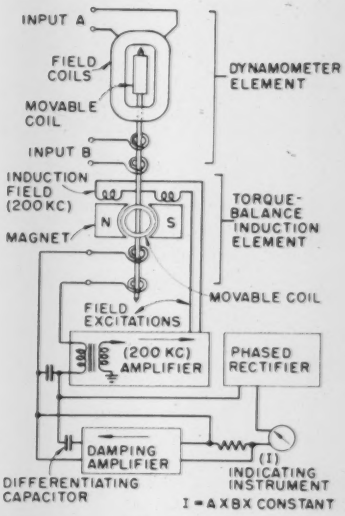


FIG. 2. SCHEMATIC diagram of the Inductronic Electrodynamometer.

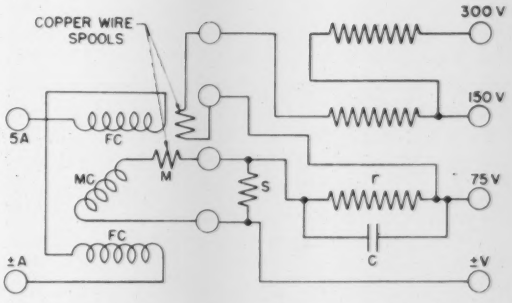


FIG. 3. WIRING DIAGRAM of wattmeter potential and current circuits.

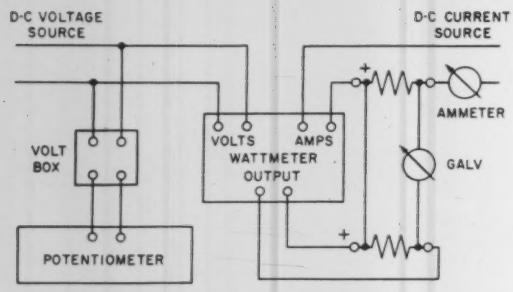


FIG. 4. CONNECTION for standardizing wattmeter using direct current, one potentiometer and two resistors.

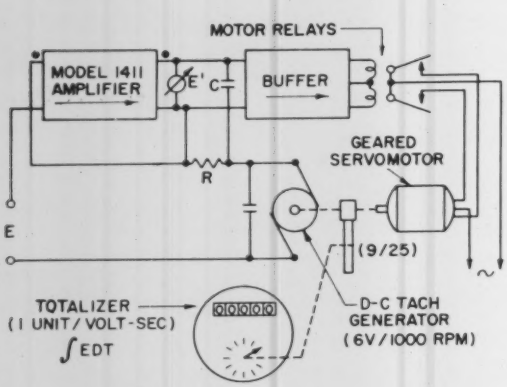


FIG. 5. DIAGRAM of precision integrator.

Use as Wattmeter

The wattmeter uses a moving coil having a nominal rating of 25 ma connected in series with resistor sheets as used in the voltmeter. The field coil is wound for 5 amperes or lower.

A source of wattmeter error is the defect angle in the potential circuit. This is caused by the inductance of the moving coil which causes the potential-circuit current to lag the applied voltage by an angle equal to $\tan^{-1} L_m/R$, where R is the potential-circuit resistance and L_m is the moving-coil inductance. This can be compensated by shunting the series resistance with a capacitor $C = L_m/r^2$, where r is equal to the resistance shunted by capacitor C. This compensates for the potential-circuit defect angle, leaving only the current-circuit defect angle caused by the eddy currents, which can be compensated by shunting the moving coil with a high resistance (Fig. 3).

The wattmeter can be standardized on direct current by using a precise voltage source and two four-terminal resistors or shunts (Fig. 4). One shunt is connected in series with the current circuit and other is connected across the d-c output terminals. The two shunts are connected together to compare voltage drops by means of a sensitive galvanometer. Direct current of the approximate value desired is applied to the field coils and a direct voltage is applied to the potential circuit and varied until the galvanometer between the shunts reads zero. The error is then the difference between the voltage applied and the rated voltage. Changes in current will not affect the balance because the voltage drop on both resistors will go up and down together for changes in current. Thus the wattmeter can be standardized by using one precision potentiometer.

Use as Watthour Meter

Watthours are measured by connecting the output current of the wattmeter to a resistor to provide a millivolt drop of 0-50 mv. This voltage is then applied to a precision integrator which measures the time integral of the voltage (Fig. 5).

The combination of Inductronic wattmeter and integrator has been tested under actual field conditions to determine its suitability for measuring turbine efficiencies. This test was performed by the Engineers of the Long Island Lighting Company at their Barrett Power Station.

Five tests were run with indicating wattmeters in each of three phases, and with one Inductronic wattmeter and integrator in phase A. The test time varied from one to three hours. The integrator was read at the beginning and end of each test and the wattmeters were read every minute.

The largest difference between the two watthour readings by each method was 0.12%. The average difference for all five tests was 0.08%. It is believed that using Inductronic wattmeters in the other two phases, and feeding the outputs to three integrators, would have provided total generator output in kilowatt-hours to an accuracy of approximately 0.1%. The output of the three wattmeters also can be connected to one integrator to provide the total three-phase energy. This may not be convenient where transformer correction factors must be applied for each phase, and where it is desirable to know the load balance.

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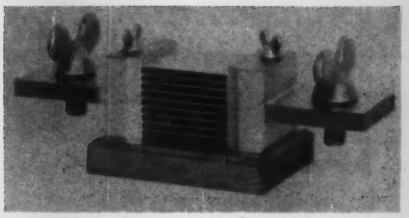
RANGE FACTORS



Instrument shunt

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SHUNTS, TRANSFORMERS AND VOLTAGE DROPPING RESISTORS can be used to measure currents and voltages above the design ratings of electrical indicators—but certain precautions must be observed.

Design and production factors limit the maximum ratings of most switchboard-type instruments as follows:

AC—750 volts, 20 amperes
DC—750 volts, 60 amperes

These ratings apply to switchboard ammeters and voltmeters as well as to a-c wattmeters. They also apply to the current and potential circuits of a-c varmeters and power-factor meters. Frequency meters and synchroscopes are normally rated at only 120 volts ac.

Higher a-c voltages require *potential transformers;* higher alternating currents require *current transformers.*

Current transformers are normally rated with a secondary of 5 amperes. This allows selection of a switchboard instrument rated 0-5 amperes, but whose scale is marked in accordance with the primary rating of the current transformer—that is, a "transformer-rated" instrument.

This is also true of voltmeters above the maximum a-c voltage rating of 750 volts. Potential transformers normally have a secondary rated at 150 volts. This allows selection of a voltmeter with 0-150 volts rating but with the scale marked in the primary rating of the potential transformer.

Wattmeters used on circuits having current and voltage above the maximum allowable self-contained ratings are also supplied as transformer-rated instruments with scales in accordance with the primary ratings of the current and potential transformers. This causes a complication: Operation of the instrument is in proportion to the product of voltage times current which is *in phase* with the voltage. The watts that actually provide torque to move the instrument's pointer are called calibrating watts. A minimum of approximately 400 watts is required to calibrate a standard 5-ampere 120-volt wattmeter.

When a wattmeter is to be used with instrument transformers to measure large amounts of power, we speak of "calibrating watts" and "scale watts." This is to differentiate between the power used by the wattmeter itself (calibrating watts) and the power transmitted through the actual circuit (scale watts). Calibrating watts for a standard zero-left instrument range between 400 to 625. This range is the actual range in watts over which the instrument can be calibrated. In order to select scale watts which will allow proper calibrating watts, the following formula can be used:

$$\text{Cal. Watts} = (\text{Scale Watts})/(\text{P-T Ratio})(\text{C-T Ratio})(K)$$

where P-T is potential transformer, C-T is current transformer, and K for single-phase and two-phase circuits equals 1; for three-phase three-wire circuits it equals 2; and for 3-phase 4-wire circuits it equals 4. Thus, the actual scale watts can be properly selected by making certain they fall within the range of possible calibrating watts of the instrument.

If the desired scale range and transformer ratios do not give a value of calibrating watts within limits shown of the standard rating, there are four alternatives:

(a) Change the scale range.
(b) Change the current transformer ratio.
(c) Supply instrument with special rated current coils.
(d) Supply instrument with lower power factor calibration.

With zero-center wattmeters, the minimum scale limit is exactly ½ of that of the zero-left scale instrument of comparable current and voltage ratings.

To measure current above 60 amperes dc, an external shunt and millivoltmeter is used. The shunt should be selected for the proper current rating and provide a millivolt output (usually 50 or 100 millivolts). An instrument with the millivolt rating of the shunt can be supplied with a scale marked in accordance with the maximum current rating of the shunts.

Voltmeters above the maximum self-contained d-c rating can be supplied with external resistors which drop the voltage to the nominal voltage value. The instrument selected is usually a 1-ma d-c instrument with the scale marked in terms of the maximum line voltage.

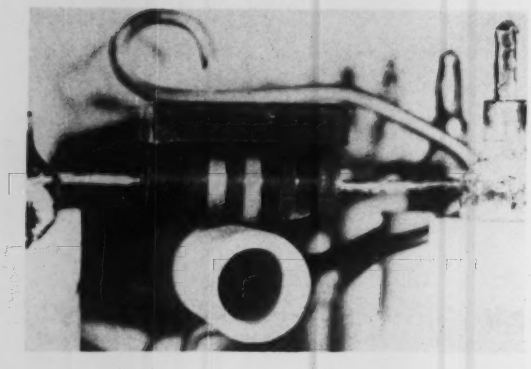

FIG. 1. END VIEW of mounting assembly, showing rubber strap, insulating rod, and spring clip.

Insulation-Resistance Measurement

A STUDY of the problem of insulation resistance measurements on carbon-composition resistors disclosed variations in resistance readings that were due to variations in (1) contact area, (2) test voltage, (3) electrification time, and (4) resistor surface conditions.

Contact Area

Variation in contact area is a function of the ability of the contacting device to conform to the irregularities of the resistor surface. Rigidity of the contacting device causes the contact to vary from point contacts on the color-code bands of the resistors to inconsistent fractions of the resistor surface. To minimize such variations the polarizing strap of MIL-R-10509B was replaced with a flat stainless-steel strap, to one side of which was bonded a 0.075-inch layer of resilient, electrically conductive, moisture-resistant silicone rubber. The mounting technique is shown in Fig. 1. This technique conforms to the procedure specified in MIL-R-10509B and retains the advantage of easy removal for subcycling during the moisture resistance test.

Surface Conditions and Voltage

The problem of relating measurement variability to resistor-surface conditions and the magnitude of the test voltage was more complex. Previous work* has shown that the resistance of a dielectric is a function of surface conditions and test voltage. An experiment was designed to test this hypothesis and the assumption that the rubber-strap contacting method was an improvement. The experiment compared the variabilities contributed by (1) three resistor-body contacting methods, (2) various measurement voltages, and (3) resistor-body surface conditions. The three contacting methods were the V-strap, the metal foil, and the conducting-rubber methods of resistor-body contact. Measurement voltages were 500 and 85 volts dc, and wet- and dry-surface conditions were established on the resistor body. The wet-surface resistor body was developed in a moisture chamber. The dry-surface resistor body was that condition which existed after the resistor was subjected to a blast of high-pressure air to remove actual moisture condensation. This blast was of short duration so that actual drying of the internal parts of the resistor did not take place. By holding the measurement time constant, it was possible to defer the problem of variability due to electrification time until after the best mounting method was determined.

Experimental Results

An experimental evaluation was performed using a homogenous sample of 120 carbon-composition resistors divided equally among the 12 different techniques that were possible using the seven conditions mentioned above. Insulation resistance was measured with an ohmmeter-type instrument* after all groups of resistors had been exposed to five standard moisture-resistance cycles as specified in Method 106 of MIL-STD-202A. The computed variance of the readings of each group of resistors was arrayed, and a test for significant differences was performed.

The group of techniques for which variances were the least consisted largely of techniques using the rubber-strap contacting method, the higher test voltage, and the dry condition of the resistor body. The largest variances were found in the foil and V-strap contacting methods, the lower test voltage, and the moist condition of the resistor body. The fact that variance trends were established that could be related to measurement techniques substantiates the initial assumption that the sample resistors evaluated were homogeneous. The results of this evaluation led to the adoption of the rubber-strap body contact

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*Twenty Million Megohmmeter, Electronics Instruments Ltd.

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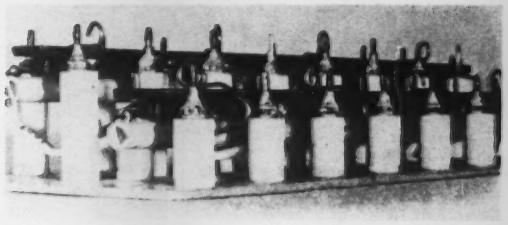

FIG. 2. PANEL accommodating sixteen resistors.

Technique for Carbon-Composition Resistors

method, the use of the 500-volt test voltage, and the dry-body conditions for the study of the effect of electrification time.

Electrification Time

Electrification time, or the time after application of the test voltage that the insulation resistance measurement is made, imposes a variance in the insulation resistance measurement because the currents which flow through the insulation material are functions of time.

Studies of electrification time revealed that the current that flows through the insulation during insulation resistance measurements is the sum of (1) a capacitive charging current (2) a dielectric absorption current, and (3) a leakage current. For carbon-composition resistors the capacitance existing between the resistor-body contacting material and the resistor element is so small that the capacitive charging current is negligible after a few microseconds. The dielectric absorption current was found to be a linear function of time, but becomes erratic as time increases. Leakage current is constant and is the steady-state current that eventually flows in the measurement circuit.

The choice of an electrification time would be arbitrary if the dielectric absorption current were a smooth, linear function of time. As this is not true the choice of an electrification time that would provide minimum variability in the insulation resistance measurements must be a time after the capacitive charging current becomes negligible and before the dielectric absorption current becomes erratic, assuming that the leakage current is constant.

Fifty carbon-composition resistors were subjected to several cycles of the standard moisture-resistance test as specified in Method 106 of MIL-STD-202A, and insulation resistance measurements were made at intervals of 10, 20, 30 and 40 seconds after the application of the test voltage. A time shorter than 10 seconds was not used because the sensitivity of the measuring equipment made an 8-second damping period necessary.

Variance analyses were made for each of the four time groups. The results of these analyses are given in Table 1. An electrification time of 10 seconds produces minimum variability.

TABLE 1—ANALYSIS OF VARIANCE OF ELECTRIFICATION TIME

Electrification Time (seconds)	Variance
10	0.326
20	1.141
30	1.139
40	1.164

Conclusions

The results of this program as described above suggest that insulation resistance measurements on carbon-composition resistors will have a minimum variability when the following experimental technique is used:

Contact to the resistor body is made with a resilient conductive silicone rubber; test voltage is 500 volts; the insulation resistance measurement is made 10 seconds after the application of the test voltage. Previous to the application of the test voltage the resistors should be freed of condensed moisture with a blast of high-pressure air.

This measurement technique provides more meaningful results because the variability observed is then more indicative of the actual variability of the resistors being measured.

Acknowledgements

The program described above has been carried on under Signal Corps Contract DA-36-039-SC-73212 under sponsorship of the U. S. Army Signal Equipment Support Agency, Fort Monmouth, New Jersey. The authors are grateful for the help received from the Sponsoring Agency and members of the Reliability Engineering Division of Battelle Memorial Institute.

Power Plant Control Valves

Many types of automatic control valves are required for power-plant installations. The ones which present the greatest problems of specification and selection are the pressure-control, level-control, and temperature-control valves. Each installation requires individual study of the entire operating range.

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CONTROL VALVES play a role of major importance in the modern steam-electric power generating station. For example, the flow diagram in Fig. 1 shows more than 50 valves used in the following ways:

Steam safety valves hold pressures below design values in (1) boiler drums, (2) superheaters, (3) reheaters, (4) closed feedwater heaters, (5) evaporators, (6) deaerating heaters, and (7) low-pressure piping systems located downstream from pressure-reducing valves or auxiliary drive turbines.

Water pressure relief valves protect equipment such as (1) water softeners, (2) demineralizers, and (3) the channel sides of closed feedwater heaters from overpressure.

Automatic stop valves are used normally as automatic emergency shutoff valves to isolate equipment under emergency conditions. Fig. 1 illustrates the use of this type of valve for (1) high-pressure turbine, (2) low-pressure turbine, and (3) auxiliary-drive turbine protection.

Governing valves control prime mover equipment. These valves control steam flow to turbines to maintain a constant speed, load output, upstream pressure, back pressure, extraction pressure or some combination of these factors.

Pressure reducing valves maintain constant downstream pressure. This valve is sometimes employed as a dump valve to maintain a constant upstream pressure. Other applications include (1) soot blowing air or steam supply pressure control, (2) steam supply to low-pressure headers, (3) steam supply for fuel oil atomization, (4) steam supply to air and hogging ejectors, (5) air supply for house service use, (6) air supply to individual instruments and controls, (7) water pressure reducing valves for house service uses, and (8) gas supply pressure reducing.

One of the most popular uses of *automatic control valves* in the central station is for level control. This application is appropriate for (1) condenser hotwells, (2) closed feedwater heater drain controls, (3) evaporator shell makup, (4) evaporator coil drains, (5) boiler drum level, (6) deaerating heater storage tank level, (7) house service storage tank level, and (8) condensate storage level control. This includes not only the diaphragm-type or piston-type valve controlled by one or more separate control elements, but also altitude valves.

Flow-control valves are used to control (1) boiler blowdown and evaporator saline blowdown rates, (2) filter, softener and demineralizer rinse and backwash rates, and (3) boiler feed pump recirculation control.

Reverse flow valves make flow possible in one direction only. These valves are used (1) in most bleed lines to prevent overspeeding of turbines due to flashing of water in stage heaters upon loss of load, (2) on pump discharge lines to permit standby pumps to be started up at will without operating gate valves on the discharge lines, (3) on main steam leads from boilers connected to a common header to prevent accidental entry of steam to a boiler which is being inspected or repaired, (4) in boiler feed lines at the inlet to the economizer, and (5) as foot valves on pump suction lines to maintain idle pumps in a primed condition.

Vacuum breaker valves perform a function which is the reverse of safety valves or relief valves. Vacuum breaker valves protect pressure vessels or non-pressure vessels from collapse when exposed to internal vacuum conditions. They also are used as syphon breakers on loop seals and protect circulating water systems from damage due to water hammer.

Atmospheric relief valves serve as automatic overpressure control valves, and usually protect vacuum vessels, or low-pressure vessels from dangerously high pressures. Their most frequent applications in power plants are on condenser shells and deaerating heaters. These valves usually are a spring-loaded multi-port type although weight-loaded valves sometimes are employed for this service.

Presented at the Fourth International Automation Exposition, New York Coliseum, June 10, 1958.

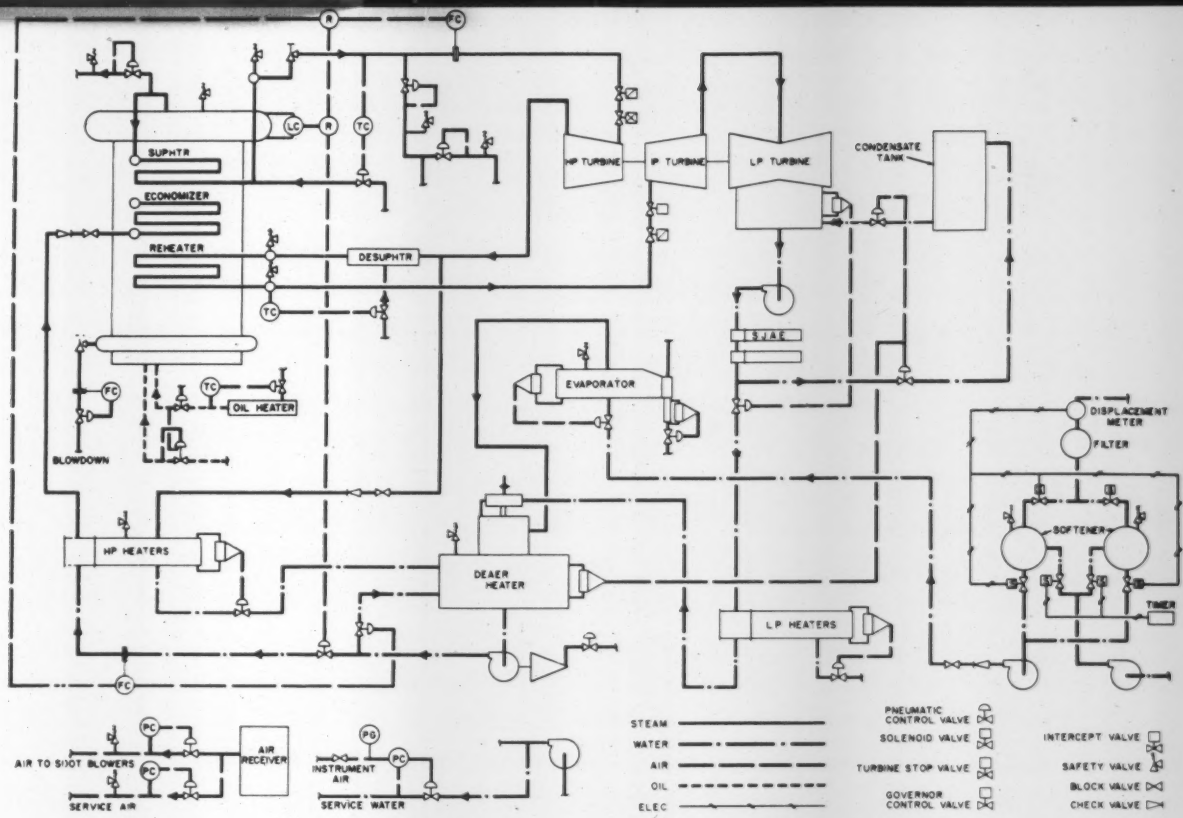


FIG. 1. CONTROL VALVE applications in power-plant service.

Temperature control valves can be found in the central station monitoring and controlling the flow of cooling water to hydrogen coolers, oil coolers, air compressor jackets and similar locations where extremes of temperature may result in damage to equipment, or inefficient operation. They also are used to control (1) steam flow to oil heating coils and air preheating coils, and (2) water flow to constant-temperature pumps.

Automatic program valves usually operate on a predetermined program established by the manufacturer or plant operator. These valves include (1) the multi-port valves usually supplied with softeners or demineralizers to control a backwash, regeneration, and rinse program, and (2) the automatic program control valves used for intermittent chlorination of circulating water supplies.

Some of the control valves to which we have referred are normally supplied as an integral part of the equipment which they serve and, consequently, are selected by the equipment manufacturer. These include safety valves, pressure relief valves, automatic stop valves, governing valves, vacuum breaker valves and automatic program valves.

Some of the valves are relatively simple in design and have limited applications in central stations. These include flow control valves, reverse flow valves and atmospheric relief valves.

The remaining group of control valves is applied to a wide variety of fluids, pressures, temperatures and circumstances. A wide variety of characteristics and designs are available and these valves must be selected and installed carefully if they are to perform satisfactorily in their specific applications. In addition to the usual decisions which must be made concerning the selection of body materials, valve trim, pipe size and primary function, specific information must be considered and compiled in preparing the specifications for the valves. We will devote the greatest portion of our attention to the pressure reducing valves, level control valves, and temperature control valves, as these present the greatest problems in selection.

Flow vs Stem Travel

It is not sufficient to establish maximum flow under a given operating condition (as is normally required for safety valves or relief valves) nor to establish maximum and minimum flow rates under extreme conditions (as is the case with automatic stop valves, reverse flow valves, vacuum breaker valves or automatic program valves). It is essential, although frequently neglected, to supply the valve manufacturer with a complete set of data showing the performance required from the valve *throughout its operating range.*

Fig. 2 shows some of the valve characteristics which are available.

Control-valve specifications frequently state that flow through the valve shall be proportional to valve stem travel. This is a desirable feature, and usually

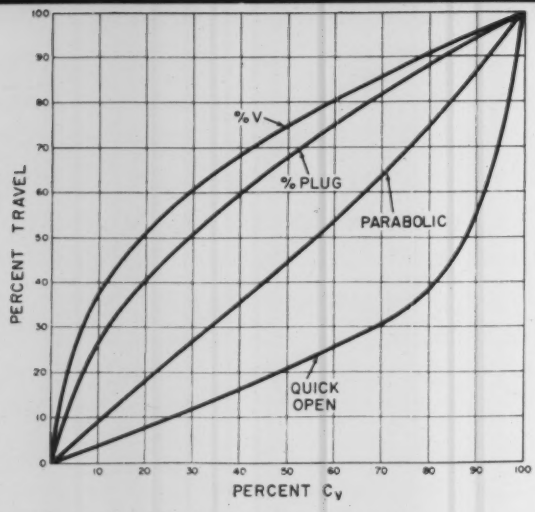


FIG. 2. VALVE characteristics available.

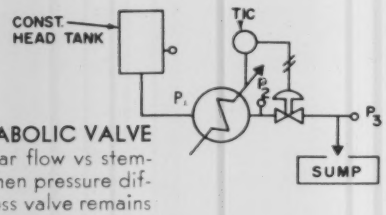
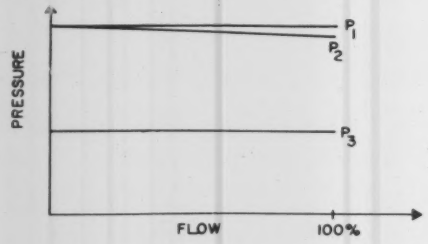
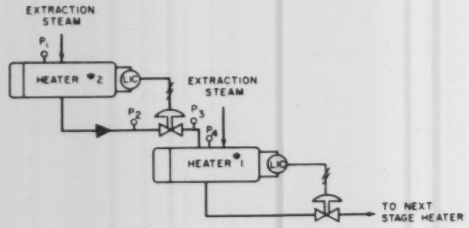


FIG. 3. PARABOLIC VALVE provides linear flow vs stem-travel only when pressure differential across valve remains constant.





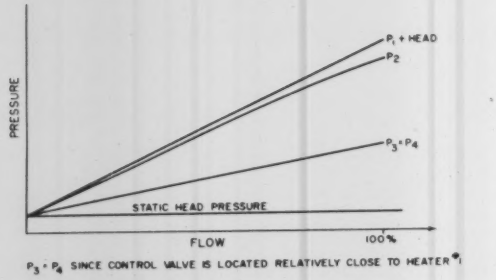


FIG. 4. WHEN PRESSURE differential increases with increasing flow, orifice opening rate must decline with greater stem travel if flow is to remain proportional to stem travel.

can be provided by a parabolic-port valve—but the manufacturer can not meet this requirement unless he is provided with reliable data over the expected range of valve operating conditions, as will be shown.

Common Flow Conditions

Fig. 3 shows a simple type of operating condition. Cold water is supplied to the valve via a heat exchanger from an elevated reservoir having a constant static head (P_1). The valve controls water flow to an open sump at atmospheric pressure (P_3). If the piping is sufficiently large, and the pressure drop through the heater is low, the pipe and heater friction can be considered to be negligible and the pressure differential across the control valve can be considered to be constant, regardless of flow. That is, P_2 is approximately equal to P_1. Under these conditions a parabolic valve will provide a flow that is linear with valve stem travel, as is usually desirable.

Fig. 4 illustrates a power-plant application where the pressure differential across the valve increases as flow increases. The drains from a high-pressure closed feedwater heater discharge through a level-control valve to a lower-pressure closed feedwater heater (in the same turbine cycle). As heater shell pressures increase in proportion to load (for most central station applications), the absolute pressure of the high-pressure heater (P_1) will rise more rapidly than that of the low-pressure heater (P_4). Hence the valve differential increases with flow and the use of a parabolic valve will no longer give flow proportional to stem travel. A quick-open valve would give a more linear response in this application.

Fig. 5 illustrates a condition where the head at the upstream face of the valve *decreases* as flow increases. The valve is located near the end of a long pipeline having appreciable pipe friction which increases with flow. The pipeline is supplied by a reservoir having constant static head, and the valve is discharging at atmospheric pressure.

This operating characteristic can be encountered also in the power plant by substituting a heat exchanger or other piece of equipment for the long pipeline, or by substituting a centrifugal pump having a dropping characteristic curve for the reservoir supply and the long pipeline. The net result is that the pressure differential across the valve decreases as flow increases. Therefore, it is necessary to open the valve orifice at an increasing rate (as by use of a percentage plug) in order to make flow rate proportional to valve stem travel.

Nonstandard Flow Conditions

Having discussed the three basic variations of valve-differential versus flow, let us look at an example which does not fit into any of these categories.

Fig. 6 shows a high-pressure closed feedwater heater being drained through a pump and level control valve to a lower-pressure floating deaerating heater that is considerably higher in elevation than the closed feedwater heater. A study of the relative heater shell pressures, heater elevations, pipe friction, density of the drains to be handled, etc., shows that the required

pumping head is relatively high at low flows, decreases at intermediate flows, and increases again at high flows (the bottom curve). The pump selected for this service, however, is a typical constant-speed centrifugal pump having a dropping characteristic curve (the upper curve). The difference between the required pumping head and the actual head supplied by the pump is the shaded area between the two curves, and represents the pressure drop across the valve for the desired flow range. A manufacturer cannot be expected to supply a valve with a characteristic suitable for providing equally sensitive control throughout this operating range without having all this data. With the data he can characterize the port properly.

Frequently control-valve specifications for this type of installation are issued with data for only the maximum flow condition. It is not surprising that more difficulty is encountered in achieving adequate heater-drain level-control in power plants than in any other level-control application.

Tight Shutoff

In addition to information concerning the differential available at various flows, the type of medium being controlled, and the temperatures and pressures to be anticipated, several other considerations must be made known to the manufacturer. One of the most important is the requirement for tight shutoff.

Frequently this is expensive to achieve, and in many cases cannot be justified economically. Tight shutoff is not too difficult for single-seated valves with small port areas and low differential operating pressures. As flows increase, valve construction is simplified and costs are lowered by use of double-ported valves. (A double-ported valve permits semi-balanced operation, with possible reduction in cost.) Double-ported valves, however, have the disadvantage of being difficult to make and keep drip tight.

There are some cases in power plant service where high maximum flows and high pressure-differentials are encountered at locations where tight shutoff is an absolute necessity. Water supply valves for desuperheating stations are in this category. It is not unusual to find two, small, single-ported valves operating in parallel for this service, even though the total valve, control and piping costs are considerably higher than that for one double-ported valve.

An alternate arrangement is the use of a double-ported valve for control purposes, installed in series with an automatic stop valve for shut-off service.

Actuating Medium

The valve manufacturer should know the characteristics of the available valve-actuating medium. This data must be more specific than just the statement that the valve shall be air or electric operated; it must include applicable voltage, current, pressure and viscosity data. An adequate description of the medium being handled will include a chemical analysis of the gas, water or oil, together with information concerning entrained solids, pH value and viscosity.

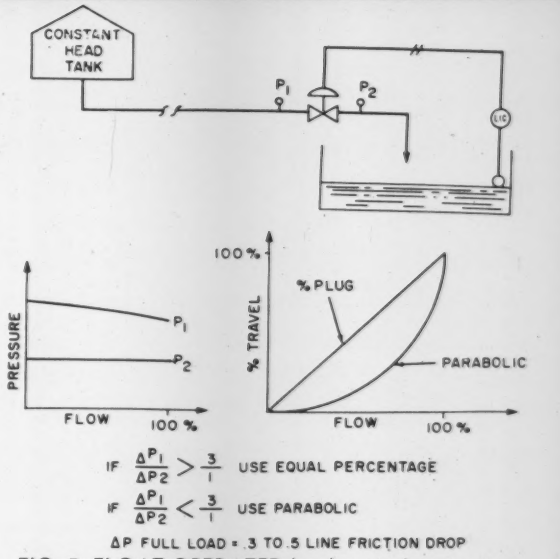


FIG. 5. FLOAT-OPERATED level control system has decreasing pressure differential across valve at increasing flow. Valve orifice must open at an increasing rate with stem travel to get flow proportional to stem travel.

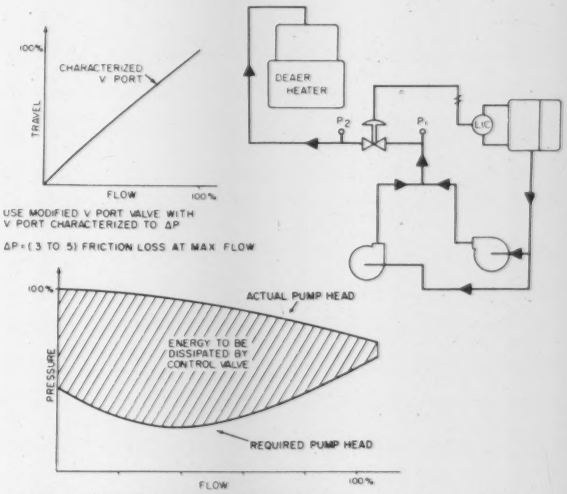


FIG. 6. PRESSURE DIFFERENTIAL at various flow rates is height of shaded portion between curves.

Positioners

One common source of unnecessary cost for control valves is the tendency of engineers to specify valve positioners for all control valves. Positioners are mandatory in many installations where high valve stem thrust is required and where close regulation is necessary. However, positioners are *not* required on valves having low stem thrusts and where a reasonable variation in control point is acceptable, as in level control for a house-service water-storage tank.

Improper Accuracy

There also has been a trend in recent years toward an excessive degree of control. A good example is use of three-element control valves for deaerating-heater storage-tank-level control. The level in deaerating heater storage tanks can be allowed to fluctuate over a wide range without affecting operating efficiency or endangering the supply of feedwater to the

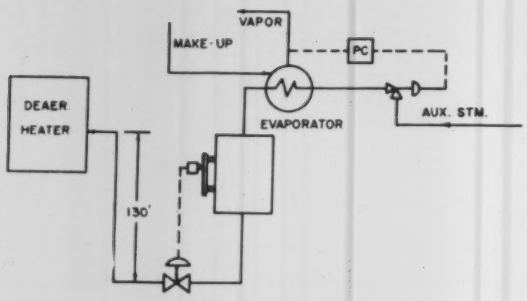


FIG. 7. EVAPORATOR liquid level control under varying tank pressures is not satisfactory.

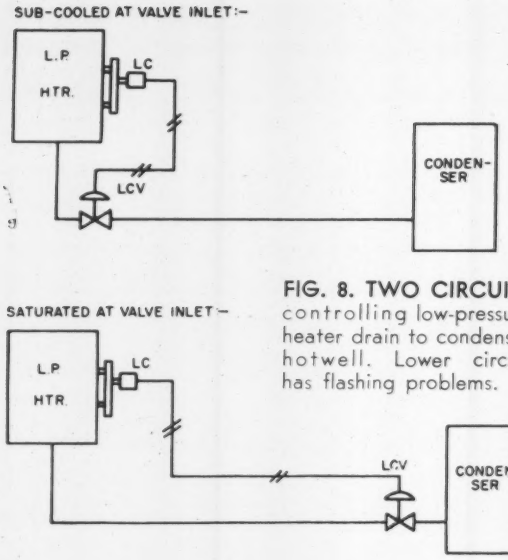


FIG. 8. TWO CIRCUITS controlling low-pressure heater drain to condenser hotwell. Lower circuit has flashing problems.

boiler feed pumps. In fact, a control which operates over a comparatively wide range is more likely to stabilize condensate pump, low-pressure heater and, consequently, turbine performance than is a sensitive control which maintains the deaerator level within unnecessarily close limits.

Coagulator Surges

A typical problem which illustrates the necessity for care and forethought in equipment installation is that encountered in locating the control element for the makeup valve to a coagulator which feeds one or more gravity filters. The water normally flows through the level control valve to a mixing chamber and from there, via gravity, to the coagulating basin. The flow through the coagulator must be slow and relatively free from agitation in order to prevent destruction of the coagulating floc. As clear wells normally supplied with coagulators are too small in proportion to the coagulator to provide for surges of output without causing similar surges at the inlet, the answer to this control problem must be found at the time of the initial design of the clear well.

It is solved by sizing the clear well sufficiently large to smooth out demand surges without causing the level control valve to fluctuate widely with resultant disturbance of the floc.

Evaporator Steam Supply

Another problem which can be traced to lack of forethought is that of installing two control valves in series without giving adequate thought to the effect of one upon the other.

Fig. 7 shows a steam control valve (right) located in the supply line to an evaporator. This valve controls steam flow to the coils to maintain a predetermined shell pressure. The drains from the coils flow by gravity to a collecting chamber. The level in the chamber is maintained by a level controller sending a loading pressure to the control valve in the drain line. The steam pressure in the supply line to the coils is sufficient to lift the coil drains to a heat exchanger at a higher elevation.

This installation cannot work satisfactorily because the steam control valve tends to throttle the steam going to the coils. This reduces the pressure in the coils and in the collecting chamber to a point where it is insufficient to raise the drains to the higher elevation required.

The sequence of events is that the coils become flooded, the evaporator shell pressure drops, the steam supply valve opens, the drains are forced to the higher elevation as the coil pressure rises, the drain valve closes, the evaporator shell pressure increases, the steam supply valve starts to close, and the drains again build up into the coils and the cycle is repeated. The net result is a surging system.

Heater Drain Flashing

The most common difficulty in the selection of heater drain valves results from the tendency of the drains to flash as they are cascaded to lower-pressure heaters or condensers. Fig. 8 illustrates the effect of changing (1) the location of the drain valve in the line and (2) the sizing of piping on valve size and performance.

The water in the heater is at saturation temperature. It does not flash in line at the bottom of the heater only because of the static head (the reason why water doesn't boil below the surface of any boiling fluid). If the valve is placed close to the heater (as at the top) the pipe friction is small and, if less than the static head, the water will not flash upstream of, or in the valve.

However, if the valve is placed at a distance from the heater, the pipe friction can exceed the static head, and the liquid will flash. Obviously, the upper illustration permits smaller valve size, cost and maintenance.

Acknowledgment is made to Mr. D. J. Lilin of Black Sivalls & Bryson, Inc. for his helpful contributions in the preparation of this paper.

Bifilar Suspension

EMIL GREIBACH, President, Greibach Instruments Corp.

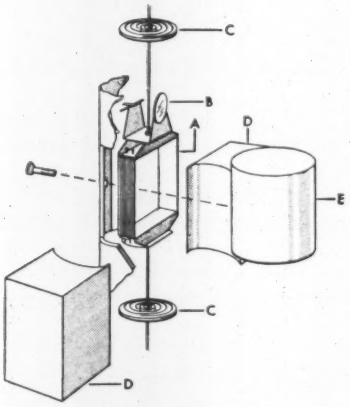


FIG. 1. MOVING COIL (A) is suspended at both ends by twin parallel wires held in tension by disc springs (C). Mirror B reflects light beam to scale.

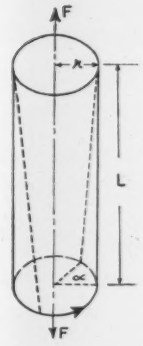


FIG. 2. ENLARGED view of suspension system shows rotation of coil through angle α.

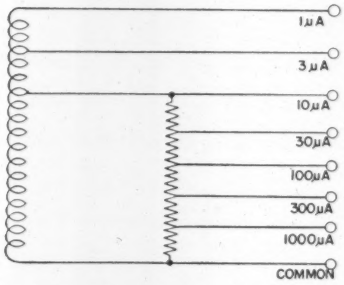


FIG. 3. SUSPENSION WIRES are independently insulated; permit tapped moving coil (left) for range changes.

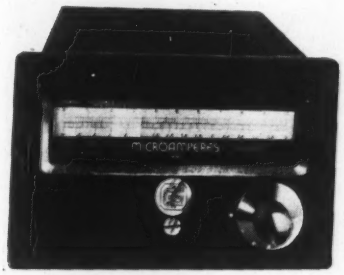


FIG. 4. LIGHT beam projects hairline on scale, without parallax.

IN THE BIFILAR SUSPENSION the moving coil of a D'Arsonval movement is suspended by two taut wires at each end. By eliminating the pivot and jewel, a friction-free movement results. The suspension wires are parallel to and symmetrically disposed about the coil's axis of rotation. The extreme ends of each pair of suspension wires are anchored in a spiral spring (Fig. 1). As the meter coil rotates in response to the torque produced by a current flowing through the suspended coil, the coil ends of the bifilar wires are rotated. This increases the wire tension provided by the strain of the spiral disc springs as their centers are pulled towards each other. The tension exerted by the disc springs on the suspension wires produces a restoring torque which tends to bring the coil back to its zero position. When the suspension wires resume their parallel alignment there is least strain in the disc springs.

The bifilar restoring torque is proportional to the square of the distance between the suspension wires, inversely proportional to the suspension length L, and a sinusoidal function of the angle α (Fig. 2). For small deflections (up to 40°) the sine curve is fairly linear, and its linearity is further improved by the linear torsional torque of the wires. The sinusoidal torque can be exploited to advantage in some special applications.

Sensitivity and Precision

As the restoring torque is proportional to r^2, high sensitivities are attainable by close spacing of the suspension wires. Suspension tension is 100 or more times the weight of the coil. The zero position is independent of temperature; it is determined by the parallel alignment of the suspension wires. Coils supported in this manner will operate in any position, thereby permitting both horizontal and vertical meters to attain the same high sensitivity.

As the deflection of the disc springs is small, the springs do not fatigue. They do not conduct current and are not affected when the meter is overloaded.

Coils and Taps

The four suspension wires are insulated from each other and serve as four conducting leads to the moving coil. Hence the moving coil also can be tapped in two places as shown in Fig. 3. This characteristic can be used to provide three ranges of current sensitivity without resorting to a universal shunt. As the number of turns at each tap is inversely proportional to the full-scale current corresponding to the tap, the millivolt drop across each coil section remains low and essentially the same for all three ranges.

Features

Standard bifilar meters withstand overload surges up to 1000 times full-scale current. For extraordinary overload risk, a special built-in protective circuit can extend the momentary overload capacity to more than 1,000,000 times the full-scale current without damage.

Bifilar meters are built to better than ¼ of 1% or better than ½ of 1% full-scale accuracy with sensitivities as high as 0.2 micro-amp full scale (6″ length) or as low as 5 amps full scale. Repeatability is better than 1/10 of 1%. Zero readjustment is seldom required.

Process Control Systems

FRED D. MARTON, Instruments Publishing Company

COMBUSTION-AIR CONTROL FOR STEAM BOILER

Combustion control in this boiler installation (Hazelwood By-Products Plant, Jones & Laughlin Steel Corp.) includes the control of air required to maintain economical combustion. The principal air control involves the speed of the forced-draft (F.D.) fan which is driven by a steam turbine. Fuel is ratioed to the air flow. (Control of fuel is discussed in another system.)

The turbine speed is controlled from a signal received from the *air-flow regulator* in response to a demand signal from the *steam-pressure controller* (Master Sender Type F). This air-flow regulator (cam-loaded diaphragm regulator) is a diaphragm type in which a cam adjusts the tension of a loading spring, which determines the regulated pressure. The regulator is connected to the boiler relay on the receiving end, and the signal remains steady as long as the received signal (air-flow demand) is balanced by the indication of actual air flow measured by the pressure drop across the boiler. If there is an unbalance, a change in signal is sent to the furnace-draft relay, which sets the induced-draft (I.D.) fan system in motion and, also, the same signal is transmitted to the F.D. fan after passing a manual/automatic control station.

The *furnace-draft relay* is a four-chamber totalizer (Hagan Type "F") which can perform derivative action. It receives a signal from the furnace-draft regulator and from the air-flow regulator. During transients this relay injects into the furnace pressure system the derivative of the air-flow-regulator control signal. This, in effect, sets the furnace draft control in motion prior to the time information is received from the pressure tap.

The *furnace-draft regulator* is of the same type as the air-flow regulator (diaphragm regulator).

The original signal from the steam header goes to the *steam pressure controller* (Master Sender Type F) containing 3 bellows units which oppose each other. It has proportional and integral mode. The varying loading pressure thus created is fed into a master relay which sends a signal into the boiler relay.

Master relay and *boiler relay* are of the same (compensating) type, equipped with a manual/automatic control station.

Failure of induced draft will energize a *solenoid* in a safety check system, interrupting the loading signal to the F.D. turbine and substituting for it a constant 30-psig air signal. This positions the forced-draft control valve at the minimum opening, slowing down the forced-draft turbine.

The *forced-draft-fan turbine steam control valve* is a Fisher diaphragm valve, equipped with a valve positioner. Upon failure of the forced-draft a safety check switch closes and actuates a Fireye control on the burner of the boiler, shutting off all fuel (described in fuel control system). Failure of induced draft also cuts off the forced draft and indirectly operates the Fireye fuel cutoffs by de-energizing a manual-reset solenoid valve installed in the loading signal line to the forced-draft-turbine steam-control valve.

The manual-automatic stations in the Master Relay and Boiler Relay allows manual control of the whole system from the panelboard.

Equipments used:

Steam Pressure Controller—Master Sender Type F (Fig. A).

Master Relay—Compensating Relay and Manual/Automatic Station (Fig. D).

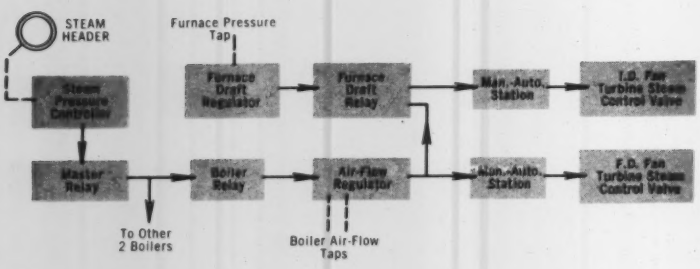
Boiler Relay—Compensating Relay and Manual/Automatic Station (Fig. D).

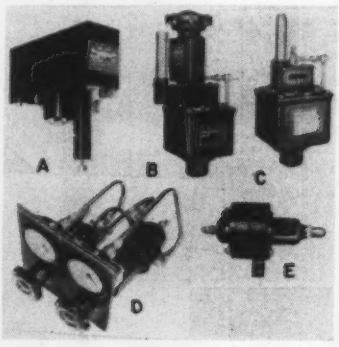
Air-Flow Regulator—Cam-loaded Diaphragm Regulator (Fig. B).

Furnace-Draft Regulator—Diaphragm Regulator (Fig. C).

Furnace Draft Relay—Totalizer Type F (Fig. E).

Source: Hagan Chemicals & Controls, Inc.; also John A. Kotsch, and Herbert W. Peth, "Highly-Automatic Steam Generation," *Instruments and Automation*, December, 1955.





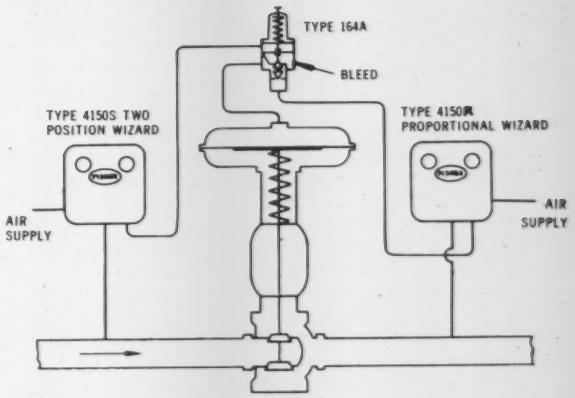
PRESSURE-REDUCING STATION HAS SELF-CLOSING FEATURE WHEN UPSTREAM PRESSURE FAILS

Application of a three-way regulating-type valve (Type 164A) in a pressure-reducing station affords a simple means of switching to close the main reducing valve in event of an undesired pressure drop in the upstream line.

The proportional controller on the downstream side of the main pressure-reducing valve is a conventional proportional pneumatic controller (Type 4150R), receiving its signal from the downstream pressure and sending a proportional pneumatic signal to the main valve (Type 657AR) to maintain the downstream pressure constant.

A two-position, on-off controller placed upstream of the valve and a small 3-way regulating-type valve are added to close the main valve in the event that the upstream pressure falls below a preset point.

Normally, the 3-way valve receives a pneumatic signal from the upstream controller, permitting the signal from the downstream controller to reach the line valve. However, when the upstream pressure falls below a preset point, the upstream controller snaps shut and no signal reaches the 3-way valve. The spring in this valve then (1) closes the port between the downstream regulator and the line valve and (2) bleeds off the pressure on top of the diaphragm of the line valve. This causes the spring in the line valve to shut it off.



The pressure reducing valve is a Type 657AR (air-to-open) which, on account of the large unbalanced forces due to the high pressure drop and the large size of the valve, is double seated.

Resetting of the valve is automatic when the upstream pressure minimum is restored.

Source: Fisher Governor Co., Marshalltown, Iowa.

COMBUSTION CONTROL BY OXYGEN ANALYSIS

The knowledge of how much oxygen is contained in flue gases furnishes an accurate indication of a combustion process. Whereas the CO_2 content, with a given excess of air, varies considerably for various commercial fuels (an individual fuel, such as coal, can show variations of as much as 1% CO_2, with constant excess air) the oxygen content with excess air remains nearly constant, independent of the fuel.

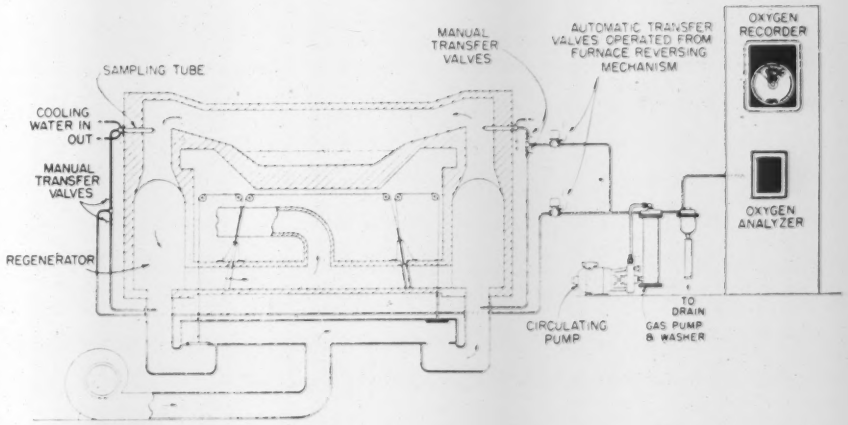
Installation of an oxygen recorder on an open-hearth furnace is shown. The *primary element* is an inductor which has an aspirator to create a partial vacuum and draw the gas sample from the furnace. To keep the sample line from burning out, fresh water is introduced near the sample point. A constant-speed pump recirculates the water (from the washer reservoir) creating a vacuum for the aspirator, scrubbing solid matter from the gas, and producing a positive pressure to force the washed gas through the piping and the analyzer.

The analyzer works on the catalytic-combustion principle, using a platinum filament. Measured quantities of flue gas and hydrogen fuel are passed over the catalyst filament. The heat liberated by combustion maintains the filament at a temperature proportional to the oxygen content of the sample.

The filament is in an a-c bridge, and any unbalance is electronically amplified. A slidewire unit re-establishes balance. The pen of the recorder is connected to the slidewire and can be calibrated in $\%O_2$,% excess air, or mixture ratio. Recorder and analyzer have an overall accuracy of 0.15% by volume.

Adjustments can be made manually or automatically to obtain efficient combustion.

Source: Bailey Meter Company, Cleveland, Ohio, Bulletin 151-A.

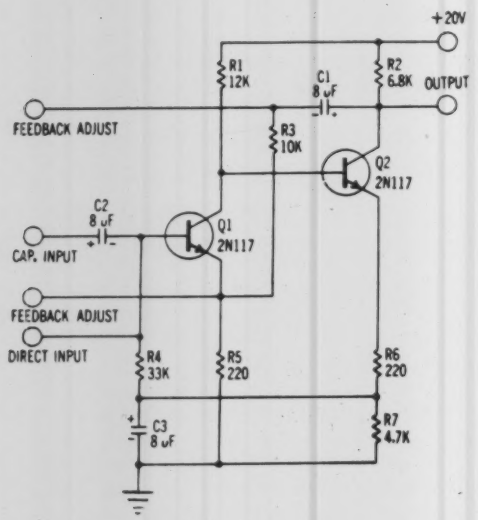


WIDE-BAND TRANSISTOR FEEDBACK AMPLIFIER IS FLAT TO 400 KC.

Silicon transistors, direct coupling, and internal feedback provide gain stabilization in this circuit throughout the operating temperature range —45° to 100°C. Frequency response is flat within two db from 25 cps to 200 kc, and is down 3 db at 400 kc. Circuit is available in plug-in module W108 from supplier.

Circuit was intended for raising the level of sine wave, complex, or transient signals to drive a squaring circuit; many other applications are possible. The two type 2N117 NPN transistors are connected in the common-emitter mode. Collector of transistor Q1 is direct-coupled to the base of Q2. Voltage feedback from the collector of transistor Q2 to the emitter of Q1 (via capacitor C1 and resistor R3) stabilizes gain and lowers output impedance. Gain stability is ±0.3 db, throughout the temperature range, and for power supply voltage changes of ±10%. Nominal gain is 36.

External frequency-compensating networks can be connected across the feedback resistor R3. For example, a



capacitor across R3 will increase the feedback at high frequencies, reducing the gain as frequency increases.

Input: For maximum undistorted output, 0.2 v peak-to peak.

Input impedance: 11,000 to 17,000 ohms; depends on frequency.

Max. driving source impedance: 400 ohms.

Output: 7.2 v peak-to-peak, max, no-load.

Output impedance: 800-1100 ohms.

Frequency response: ±1 db, 25 cps to 200 kc; down 3 db at 400 kc.

Voltage gain: 36, nominal.

Gain stability: ±0.3 db.

Total harmonic distortion: less than 2%.

Loading: For minimum distortion to 100 kc, 30K ohms minimum resistive, 300-uuf max capacitive.

Power supply: 20 v d-c at 2.5 ma; voltage tolerance ±10%.

Source: Engineered Electronics Co., 506 E. First St., Santa Ana, Calif.

ELECTRONIC

The circuit is the heart of all electronics. Here are 3 more basic and interesting circuits. Unless marked, resistors are in ohms, capacitors in microfarads.

TRANSISTOR "AND" GATE

This "And" Gate circuit has two control inputs (F and G) and two outputs. The two gates also have a common pulse input (H); this input pulse is transmitted to either or both outputs only if the respective control signal is present. Circuit is available in plug-in module T-410 from supplier (numbers in circle refer to pins on module).

The two emitter-followers are gated by application of the control signal inputs to their bases. As the 2N438 transistors are NPN types, polarity of supply and signal voltages corresponds to those in the familiar vacuum-tube cathode-follower. When control input G is at the "off" level of —11v, transistor Q2 is cut off because its emitter is returned to 4.3-v dc via resistor R7 and R8, while its base is held at the —11 v level.

If a pulse (9-v max amplitude, 0.25-usec rise time) is applied to the pulse input during this time, the transistor remains cutoff and the pulse does not appear at the output. However, when the control input is brought to the "ON" level of —3 v, the emitter follower conducts, and an applied pulse reaching the base via capacitor C2 is faithfully reproduced at the output. Emitter follower Q1 operates in the same way on the common pulse input, but has its own control input (F) and signal output (K).

Inherent delays in the circuit occur in enabling and disabling the gates. Each gate is enabled 2.0 usec after application of the —3-v dc signal to its control input; disabling occurs 4.0 usec after the control input has been returned to —11 v dc. These inherent delays are desirable in computer applications because they make possible many trigger and logic operations which must occur simultaneously.

Pulse inputs normally are applied from a pulse amplifier, pulse inverter, squaring amplifier, blocking oscillator, or NPN emitter follower. Typical uses for the pulse outputs are triggering one flip-flop or resetting up to three flip-flops.

Inputs (control):

Amplitude: Level shift of 8 v dc, from —11 to - ` v nominal.

Rise time: 0.2 to 1.0 usec.

Gate enable time: 2.0 usec.

Gate disable time: 4.0 usec.

Input impedance: To a-c: 1K and 180 uuf in series; to dc: 0.9 ma max to a negative voltage.

Pulse input:

Amplitude: 7.5 to 9.0 v peak-to-peak, positive-going.

Frequency: Up to 250 kc.

Rise time: 0.25 usec or less.

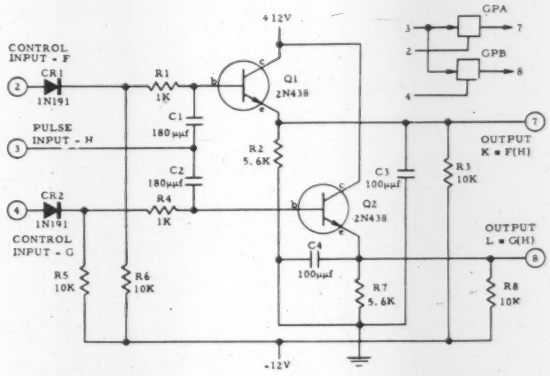
Input impedance: 360 uuf capacitive.

CIRCUITRY

CHARLES F. KEZER

and

MILTON H. ARONSON



Outputs: Positive pulses

Amplitude: 4.5 v peak-to-peak under load.

Rise time: 0.25 usec or better (essentially equal to pulse input rise time).

Pulse Duration: 0.75 usec nominal.

Power supply: —12 v dc at 1.8 ma, +12 v dc at 0.8 ma. Voltage tolerance is ±10%.

Source: Engineered Electronics Company, 506 East First St., Santa Ana, Calif.

TRANSISTOR PHONO PREAMPLIFIER-DRIVER

This preamplifier is capable of driving a 7-watt power amplifier, providing compensation for a popular type of phono pickup reproducing records recorded to the RIAA standards. Bass and treble tone controls are also provided. Transistors are all GE2N190.

Transistors are well suited to the low-level stages of phono preamplifiers because there is no problem of hum pickup as there is from the heater circuits of tubes. To obtain wide frequency-response and low distortion, negative feedback must be used around conventional transistor amplifiers. Two feedback pairs are used in this circuit, with the tone controls between them. The output feedback pair (TR_3 and TR_4) is connected for flat frequency response. The feedback pair TR_1 and TR_2, however, provide rising frequency response at low frequencies to match the recording characteristic. This response is obtained with the proper value of capacitor C4. If C4 were made much larger, the feedback current would be independent of frequency, and a flat response would be obtained. With a small value of C4, however, feedback current is reduced at low frequencies (because of higher capacitive reactance), and the gain rises, providing the desired characteristic.

In each feedback pair in this circuit the feedback voltage is developed at the emitter of the second stage. This voltage is proportional to the output *current* of the amplifier; this is desirable as it is the *current* into the next stage which must be controlled. If a transistor preamplifier were used to drive a vacuum-tube amplifier, voltage feedback (developed at the collector) should be used.

Tone-control circuits for transistors are somewhat different from vacuum-tube tone controls because of the lower impedance levels of transistor circuits. Their action is more easily understood if they are considered as current transfer networks rather than voltage transfer networks as in vacuum-tube circuits. At 1 kc, the tone controls have little effect; most of the input current is shunted to ground, with only 1/11 of the input current passed along to the next transistor (TR_3). At low frequencies, with bass control R10 near the top, capacitor C6 is shunted out, producing bass boost. When R10 is turned down, the high impedance of C6 (at low frequencies) reduces bass response.

Operation of the treble control is similar: with R13 turned down, signal is shunted (at high frequencies) through capacitor C9. With R13 rotated the other direction, high frequencies are given a boost (with respect to 1-kc signals) via capacitor C8. Range of tone controls is approximately ±15 db at 20 cps and 20 kc.

Power supply: —30 v dc at 4 ma.

Output: Operates only into power amplifier.

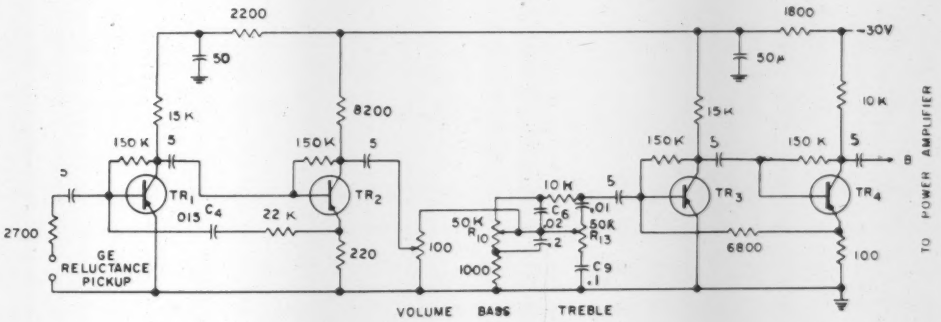
Input impedance: 5K to 6K ohms.

Frequency response: RIAA standard recording characteristic, bass and treble adjustable ±15 db, 20 cps to 20 kc.

Input for full output: 10 mv.

Distortion: <1%

Source: *Transistor Manual*, 2d edition, General Electric Co., Semiconductor Products, 1224 W. Genessee St., Syracuse, N. Y.



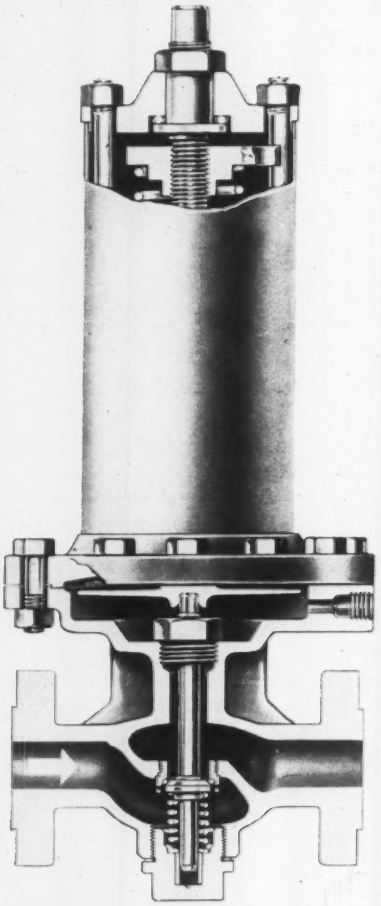
NOW ADDED TO LESLIE's COMPLETE LINE...

TWO NEW CONCEPTS IN

NEW LESLIE-TOPPER® VALVE DESIGNED WITH PILOTING DEVICE ENTIRELY *OUT OF THE PATH OF STEAM*

The new Leslie Topper self-contained pressure reducing valve offers a new level of accuracy, simplicity and low-maintenance service (see chart below). Key to this revolutionary valve is a piloting device which is entirely out of the path of steam. Because this mechanical pilot is sealed-off from the steam and all valve parts are designed without dirt-catching passages, the new Topper valve is ideal for both poor steam conditions and intermittent duty.

It can handle low-reduced pressures and is used in process lines, steam heat reducing stations and for make-up steam supply to heaters, gland sealing system and process equipment. You benefit from added reliability, plus the accuracy of a pilot operated valve and the rugged simplicity of direct operation. It means less shut-down time for maintenance, surer pressure control and increased plant efficiency.



SPECIFICATIONS

Sizes, Body Materials and End Connection:
½—2", cast iron, and bronze, screwed, 150 and 300 lb. bronze, flanged.
1—2" 125 and 250 lb. cast iron, flanged bodies.

Three Spring Ranges: *2-10 psi; 5-20 psi; 15-35 psi.*

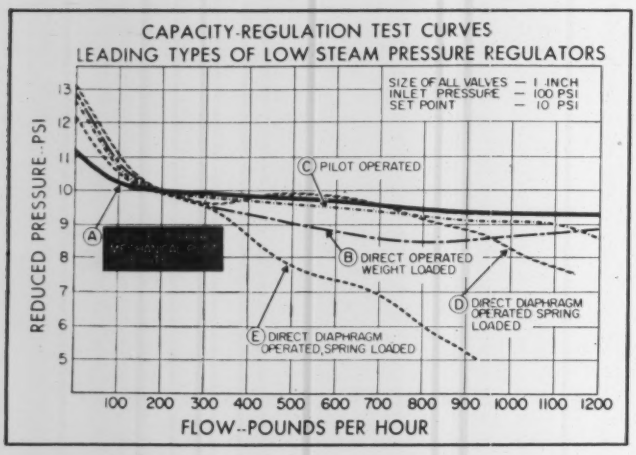
Long-travel metal diaphragm: *2 ply, phosphor bronze, Spiro-flex.®*

Main Valve: *Hardened 440C stainless steel.*

Seat Ring: *Stellited stainless steel.*

Stem Guides: *Gun metal bronze (top and bottom guided).*

Main Valve Spring: *Inconel.*



For sizing and capacity data, contact your Leslie Engineer or write for Bulletin 582.

LC-8

CIRCLE 69 ON READER-SERVICE CARD

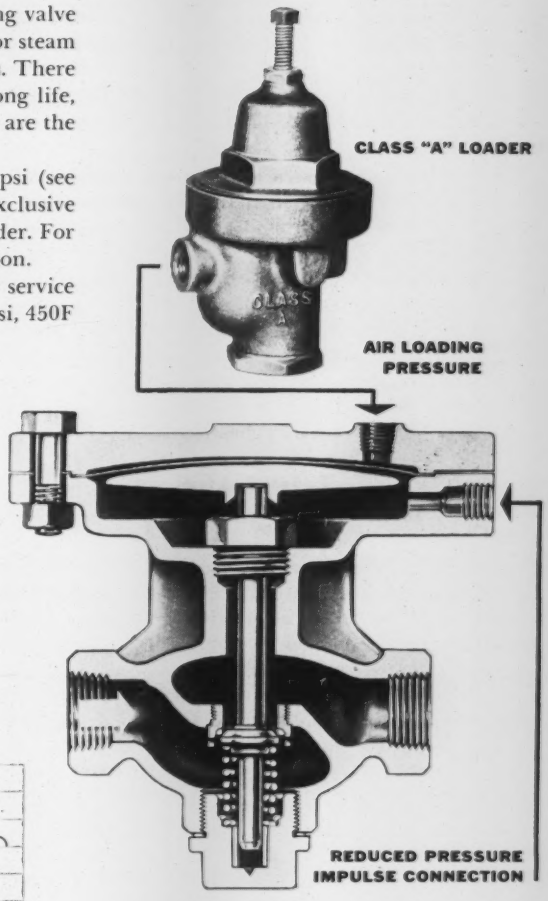
PRESSURE REDUCING VALVES

LESLIE AIR-LOADED REDUCING VALVE GUARANTEED MAINTENANCE-FREE FOR THREE FULL YEARS

New Leslie air-top GPK diaphragm operated, pressure reducing valve is guaranteed maintenance-free for three full years. Designed for steam heat or process steam application, it has only two moving parts. There are no seals, no stuffing boxes, no small dirt catching parts. Long life, long-travel diaphragm and hardened stainless steel main valve are the only parts that move.

You get accurate response even to flow changes as small as 0.1 psi (see chart below). This exceptional responsiveness results from exclusive diaphragm design and the accuracy of the simple Leslie air loader. For added flexibility, pressure can be adjusted from remote location.

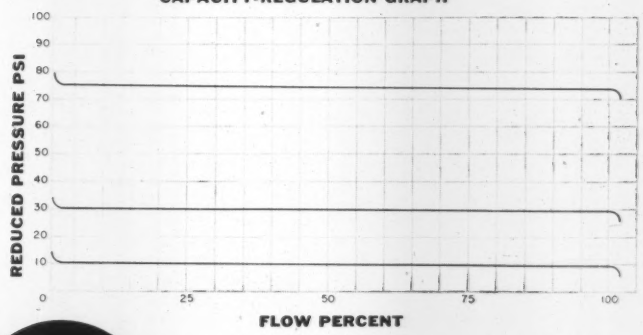
Especially desirable for poor steam conditions and standby service requirements, the GPK is suitable for steam service up to 250 psi, 450F and is available in ½" to 4" sizes.



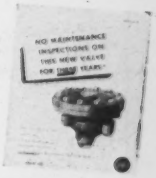
SPECIFICATIONS

Sizes: *½ to 2", cast iron or bronze, screwed ends. 2½, 3 and 4", cast iron, 125 or 250 lb. flanged.*
Main Valve: *Hardened 440C Stainless Steel.*
Seat Ring: *Stellited Stainless Steel.*
Stem Guides: *Gun Metal Bronze (top and bottom guided).*
Main Valve Spring: *Inconel.*
Inlet Pressure Range: *0-250 psi, 450°F.*
Reduced Pressure Range: *0-85 psi with Class A loader, up to 249 ½ psi with any suitable high pressure loader.*
Minimum Pressure Drop across Valve: *½ psi.*
Available with manual opening device in sizes ½—1¼".

CAPACITY-REGULATION GRAPH



For sizing and capacity data, contact your Leslie Engineer or write for Bulletin 561-B.



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CIRCLE 69 ON READER-SERVICE CARD

Journal of the S C M A . . .

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Gamma Rays Measure Level and Density

O. W. GRAHAM, President, Instruments, Inc.

RADIOACTIVITY was first discovered in 1896. One of the first applications was radiography, where pitchblend was used to make photographs of metal structures, much as doctors use X-ray today to study bone structure.

After Madam Curie made known her method of refining ores containing radium chloride, gamma-ray sources were made small enough that they became practical working tools. Today, radium is a useful source for gamma rays, beta rays and alpha particles. The highly penetrating gamma rays are employed in the following industrial applications.

Level Control

Fig. 1 shows a typical arrangement of components for measuring level in a closed vessel by radiation. The several radium sources are placed in thermowells extending inside the vessel; the counter tube (radiation detector) is placed on the exterior of the vessel, a fixed distance above the top sources. The impulses transmitted from the radium sources through the vessel wall are detected by the counter tube, amplified, transmitted to an integrating amplifier and recorder or indicator.

Presented at 8th Annual SCMA-LAHJC Short Course, March 1959.

When the material in the vessel covers the sources, part of the emission is absorbed. This change in the amount of radiation detected by the counter tube is shown by the indicator as a change in level.

The radiation sources are spaced at fixed intervals along the vessel wall, separated by a distance determined by the density of the material. Spacing between each source is that required for the material to absorb 90% of the source emission. Where the density of the material does not exceed one, the source spacing is approximately 2′. Enough sources are installed to provide the range desired.

Fig. 2 shows the location of multiple sources in a difficult application controlling of the bed level in a catalytic cracking unit in a reaction section. Vessel diameter was 16′; the wall was 3″ of steel with 12″ of nickel-base asbestos. The absorption of this material was so high that it was necessary to locate the detector on the opposite side of the vessel from the sources, which were mounted close to each other. Total range measured in this application was 6′.

Fig. 3 shows source spacing on a vessel containing bead catalyst, where the detector could be located

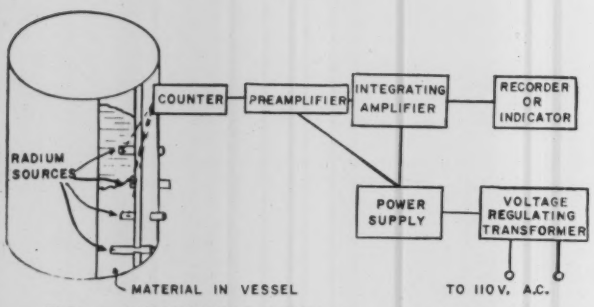


FIG. 1. MEASURING LEVEL in a closed vessel by radiation.

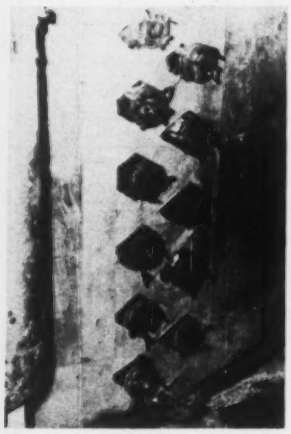


FIG. 2. SOURCES in a cracker.

FIG. 3. SOURCES on catalyst vessel.

directly above the source wells. Fig. 4 is a calibration curve showing the amount of radium required at the source holders for the bead catalyst installation shown in Fig. 3. Fig. 5 shows a chart record taken from this catalyst storage bin installation; the sharp peaks indicate the filling and emptying of the catalyst storage bin during start-up.

Fig. 6 shows a plug-in counter tube. It is 4″ long and contains a 3-mil tungsten wire anode; the copper cylinder is the cathode. The tubes are filled with pure hydrogen. No quenching gas is used so the life of this tube is not limited by the number of counts detected, but merely by its ability to be sealed to hold the hydrogen gas. Tubes of this type have been in service for over ten years.

Owing to the amount of radium used in this refinery (twelve applications), the management provided for storage of all the source rods in the event that they were all removed from the vessels at one time. Fig. 7 shows the radium storage wells provided for the radium when not in use. This is elaborate; it is doubtful that many companies would go to the expense of providing storage for all their radium at one time. However, in installations using large amounts of radium or cobalt, consideration should be given to the safety of all personnel that might be in the area. The Atomic Energy Commission has passed a ruling recently which states that any vessel containing a radioactive isotope must have padlocks on all manways to prevent personnel from entering the vessel while the radioactive isotopes are installed on the vessel, with adequate warning signs to all personnel not to enter the vessel except under the supervision of the person responsible for radioactive isotopes in the plant.

Density

Some dairies mix air with their ice cream to improve its texture. However, the amount of air that can be used in the ice cream is critical. The air-to-ice cream mixture can vary from batch to batch making it difficult for dairies to produce ice cream of consistent quality. Radiation technique can be used to measure the density of the mixture. Dairies have many other applications for radiation instruments. Wherever difficult density problems exist, radiation technique can be considered.

Other Applications

Other applications for radiation technique include measuring the thickness of pipe and vessel walls while in service, flow measurement, and irradiation of plastics and materials to obtain properties such as increased resistance to heat.

OCTOBER MEETING NOTICE

Date: Thursday Eve., Oct. 15, 1959

Place: Rio Hondo Country Club, Downey, Calif.

Subject: M. Parr (Foxboro) will discuss **Cement Plant Instrumentation;** E. Pitt will demonstrate Foxboro products.

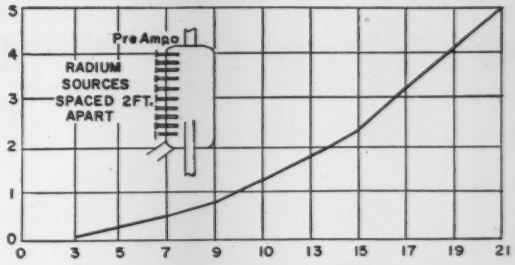


FIG. 4. AMOUNT of radium required versus distance between source and detector.

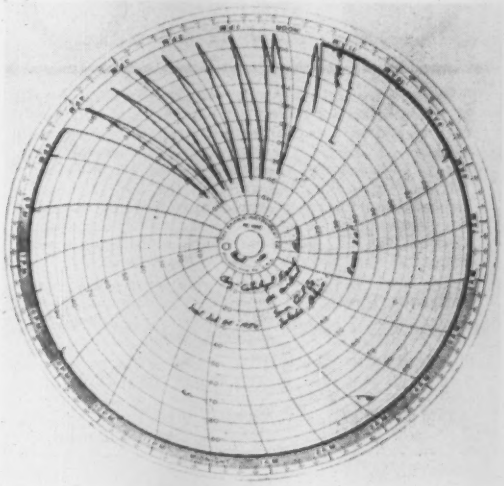


FIG. 5. Chart record.

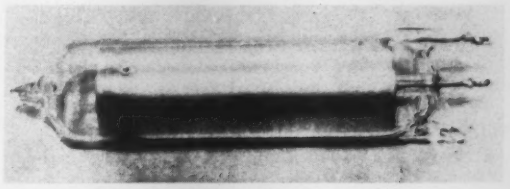


FIG. 6. PLUG-IN counter tube.

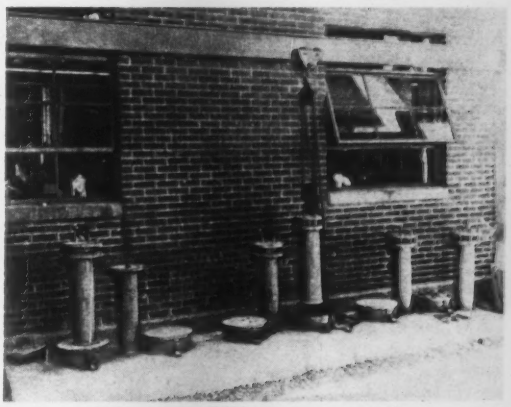
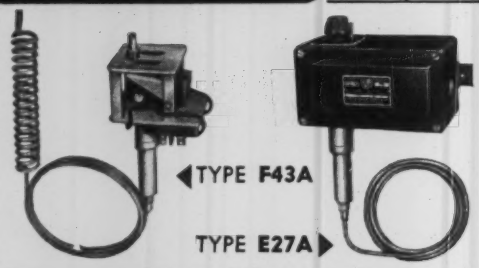


FIG. 7. RADIUM storage wells.

Correction: The paper in the July **SCMA Journal,** "A Direct-Reading Viscometer," by Montgomery Shafer, was erroneously reported as having been presented at the LAHJC-SCMA.

Dual Switch
REMOTE BULB
TEMPERATURE CONTROLS **F43A E27A**



The F43A and E27A are functionally similar units that are offered by UNITED ELECTRIC for applications where it is desirable to control two separate circuits at different temperatures by means of a single temperature control. The major differences between the two units are that the F43A is an uncalibrated, wide range, skeleton unit while the E27A is calibrated, has a narrow range, and is enclosed. If desired, the E27A can be modified to have a wide range.

Temperature Ranges . . .	F43A — up to maximum limits of −150° to +150°F., 70° to 370°F., or 100° to 650°F. E27A — 100° or 200°F. spans between −150° and +650°F. limits.
On-Off Differential	Approximately 1.0°F. or 2.0°F. depending upon the model.
Switch Ratings	Up to 15 amps. at 115 or 230 volts A.C. 20 amps. A.C. or D.C. switches also available.
Switch Types	N.O., N.C., or Double Throw — no neutral position.
Adjustments	F43A — slotted range adjustment screw on top, uncalibrated settings. E27A — external knob and pointer, calibrated settings. In each unit, switch may be adjusted individually to provide for approximately 15°F. max. span between switch settings. Span remains constant over entire range.
Electrical Connections . .	Via attached terminal blocks.
Capillary Tube Length . .	6-foot standard length. Other lengths available.
Mounting	F43A — via tapped holes in top plate. E27A — via mounting ears or tapped holes.

UNITED ELECTRIC *manufactures a complete line of temperature, pressure and vacuum controls. For special applications, standard units may be modified, or custom-built units may be provided. For additional data on remote type temperature controls, including types F43A and E27A, request* Section 200 *of our* new *catalog.*

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CIRCLE 70 ON READER-SERVICE CARD

book reviews

Frequency Response for Process Control, by 9 specialists, edited by W. I. Caldwell, G. A. Coon and L. M. Zoss, McGraw-Hill Book Co., copyright 1959 by Taylor Instrument Companies, 395 plus viii pages, $11.50. Basic math of frequency-response analysis: lead, lag, and feedback; process characteristics and controller settings.

From Euclid to Eddington, A Study of Conceptions of the External World, by Sir Edmund Whittaker, Dover Publications, 180 Varick St., N. Y. 14, N. Y., paper, 1959, 212 plus x pages, $1.35. Traces the development of physical theories—space, geometry, electron spin, etc.

Research Techniques in Human Engineering, by Alphonse Chapanis, 1959, Johns Hopkins Press, Baltimore 18, Md., 316 plus xii pages, cloth, $6.00. Covers both experimental and phsychophysical methods of examining the human in the technical system. Of value in operations research and systems engineering.

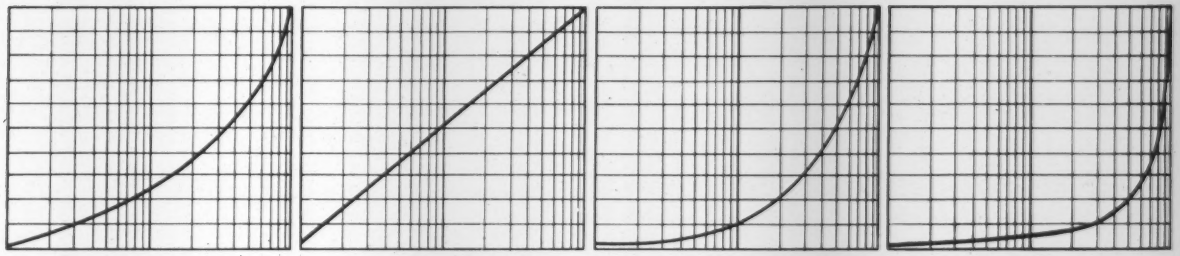
Electrical Safety, by H. W. Swann, Philosophical Library, 15 E. 40 St., N. Y. 16, N. Y., 1959, 292 plus xii pages, cloth, $15.00. A study of electrical accidents, the British Electricity Regulations, Cable, Switchboards, Regulation and Static Electricity Hazards.

The Practical Dictionary of Electricity and Electronics, by R. L. Oldfield, American Technical Society, 848 E. 58th St., Chicago 37, Ill., 1959, 216 pages with ill.; $5.95. Includes 178 pages of definitions and 38 pages of handbook data—tables, formulas, symbols. Cloth.

The Pulse of Radar, Autobiography of Sir Robert Watson-Watt, The Dial Press, 461 4th Ave., N. Y. 16, N. Y., 438 plus x pages, 1959, $6.00. Well written; shows how factors of personality, temperament and individuality affect the greatest of technical developments.

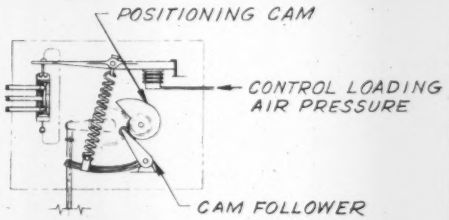
Tape Recorder Manual, Vol. 4, Catalog No. TR-4, 1959, Howard W. Sams & Co., 2201 E. 46 St., Indianapolis, Ind., $2.95. Paper. Covers selected recorders of Bell & Howell, Bell Sound, Grundig, Knight, RCA, Revere, Sylvania, Telectro, and Tower.

Continuous Analysis of Chemical Process Systems, by Sidney Siggia, John Wiley & Sons, 440 4th Ave., N. Y. 16, N. Y., 1959, $8.50. 380 plus xii pages, cloth. Basically a survey of commercially available equipments for analytical measurements.



TAKE YOUR CHOICE!

ANY OF THESE (and many more) CHARACTERISTICS ARE OBTAINABLE with DeZurik CONTROL VALVES WITHOUT DISMANTLING THE VALVE!



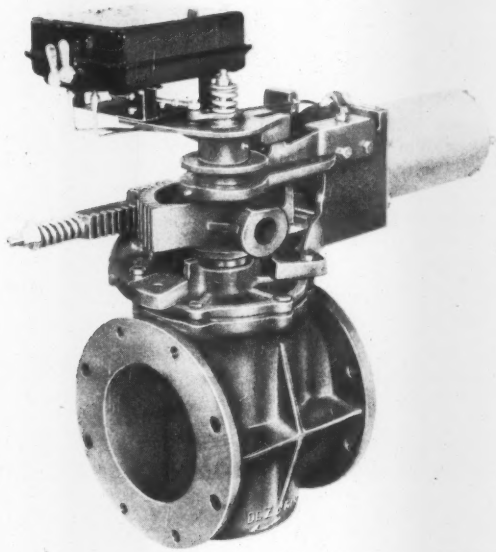
The positioning cam in the positioner is easily changed to vary the throttling characteristic. Cams can be supplied to produce virtually any desired curve, or they can be cut "on the job" to produce a characteristic tailored to the installation.

DeZurik Control Valves present an endless variety of possibilities to the instrument engineer. The characterizing feature of the positioner allows various positioning cams to be used which will produce almost any desired throttling characteristic.

The throttling characteristic may be pre-selected and the proper cam supplied with the valve from the factory, or the cam shape and resultant flow curve may be determined after installation of the valve. Changing cams is a simple operation and does not involve changing any valve part.

DeZurik Control Valves have extremely high rangeability, providing a wider control range than is available with ordinary control valves. Because of the port design and eccentric action, the flow characteristic is usable down to the shut off position.

In addition to this feature, DeZurik Control Valves offer dead-tight shut-off, higher capacity, leak-proof rotary stem seals, straight-thru flow and many other desirable features.



AVAILABLE NOW! GET THE COMPLETE STORY on DeZurik Control Valves. Ask the DeZurik representative in your area for Bulletin 150, or write Dept. CV.

DeZURIK CORPORATION
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CIRCLE 71 ON READER-SERVICE CARD

You can see and feel

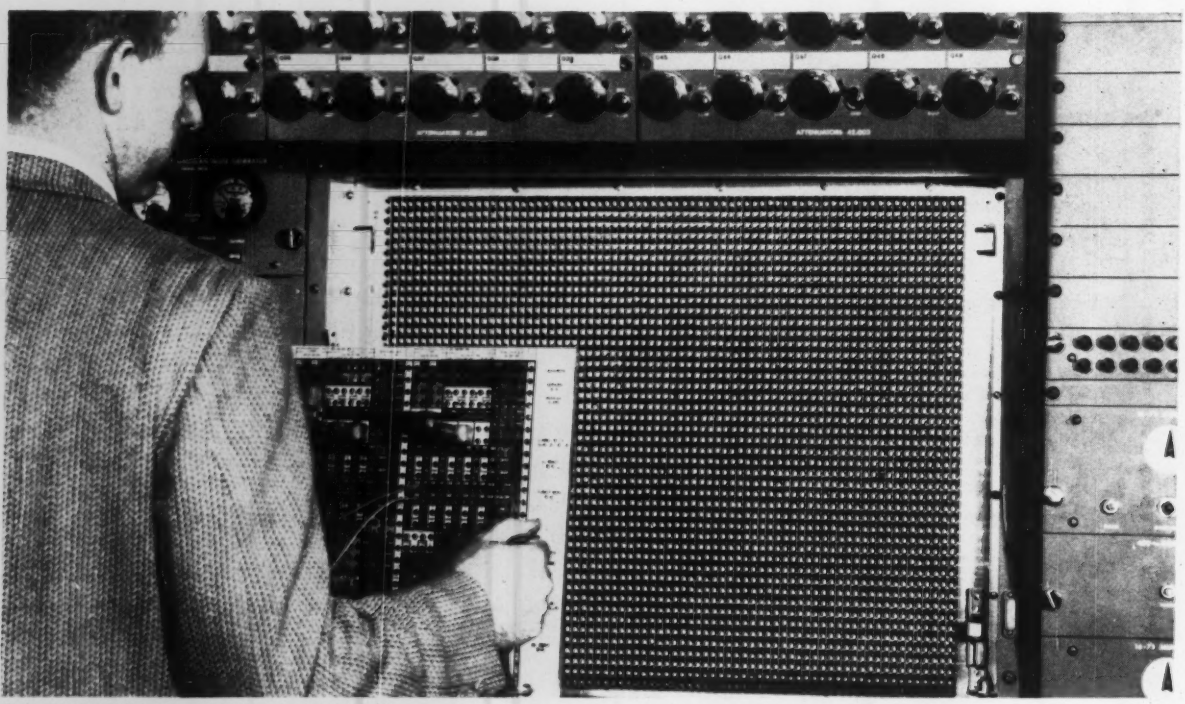
the quality in EAI's

PACE®

analog computer

There's a certain feel and appearance that goes hand-in-hand with quality and reliability. This is nowhere more evident than when you pull out the pre-patch panel in the PACE 231-R Computer. Feel the solid construction of the panel itself – notice the thousands of contacts in the patch bay, all plated with 24 carat gold. This reflects the quality built into every part of the PACE Computer.

- Solid aluminum pre-patch panel is light and easy to handle. Its 3450 holes are precision drilled to .001 of an inch. It will not warp, bend or crack.
- The rack and console are of welded, heavy gage steel construction for added protection to precision components.
- 3450 contacts in the patch bay are plated with 24 carat gold. This provides unusually good electrical contact... important for accuracy at low voltages and currents.
- Contacts are isolated from each other by cells to shield against pick-up and cross talk.



Contacts in patch bay are plated with 24 carat gold for maximum accuracy at low voltages and currents.

- Coaxial leads and individually shielded amplifiers are part of a complete shielding system that extends throughout the computer.
- Bus bar power distribution provides an added measure of reliability and simplifies inspection and maintenance.
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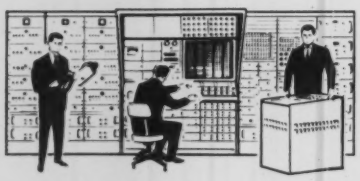

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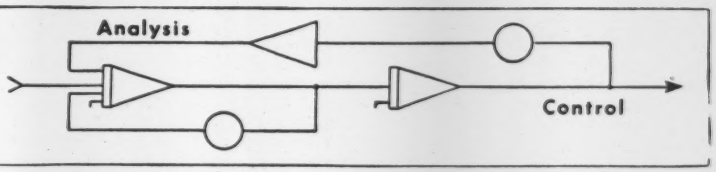
Long Branch, New Jersey

CIRCLE 72 ON READER-SERVICE CARD

The SIMULATION COUNCIL Newsletter



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8484 La Jolla Shores Drive,
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Bits

Except for a few random items of information, this month's Newsletter is devoted exclusively to the May 21st meeting of the Western Simulation Council held at the Rand Corporation in Santa Monica, Calif. At this meeting *Hans Meissinger* (Hughes Aircraft, Culver City, Calif.), *Keith Uncapher* (Rand Corp.), *Walter Karplus* (UCLA, Los Angeles, Calif.), *Floyd Steele* (Litton Industries, La Jolla, Calif.), and *Cornelius Leondes* (UCLA) discussed "Trends in Simulation." Their remarks and the discussion were recorded. Tape recording was edited by *Ed DeLand* (Rand). Ed's notes were edited by your Editor, and his notes by your Secretary. The battered remains follow!

Pieces

WESTERN S/C MEETING OF 21 MAY ON TRENDS IN SIMULATION

About 75 representatives of 32 organizations gathered at the Rand Corporation in Santa Monica, Calif. to participate in a discussion of "Trends in Simulation" at the Western Simulation Council meeting of 21 May. By way of greeting and welcome *Ed DeLand* explained that *Paul Armer*, the announced host, could not be there because he was in Russia. As the logic relating these two facts seemed rigorously defensible, and the second one amenable to proof (and as a cursory check seemed to indicate that Paul was indeed not present), it was decided to accept Ed's statement and get on with the meeting.

Irwin Pfeffer (Space Technology Laboratories, Los Angeles 45, Calif.), Chairman of the Western Simulation Council, called on the first speaker, *Hans Meissinger*.

Meissinger on Trends

"I think we ought to address ourselves to this task by being open-minded. We know that all types of computers are here to stay, and that each one has its particular function. There might be some areas of overlap. However, I would like to point out how the different kinds of computers really complement each other. The one used should be selected to fit the engineering or mathematical needs of the user. Probably most people here are more familiar with analog computers than with digital, because the analog are more often used for simulation. But I will also take into account the areas where simulation ought to be done digitally. One of the primary objects of our panel is to examine the pattern of usage of analog or digital computers.

"Economy is important, and it's a fact of life that the digital computers are expensive; analog computers may be expensive or not, depending on how large a computer you want. In the case of Hughes Aircraft, per-diem expenditure for the machine, not counting overhead, is probably $350 for IBM equipment of the 709 type compared with $50 for the large analog. Mind you, this is one analog computer big enough to handle problems similar to those that the IBM 709 would handle, but certainly not able to do exactly the same kind of computations. Common sense must be used; we could not possibly use a digital computer of the magnitude of the 709 to conduct a trial-and-error experiment as we often like to do in engineering problems.

"It's just not feasible to let a computer of that type stand idle for 15 minutes while you decide on another way of attacking the problem. We can and often do it, however, with analog computers.

"I'd like to point out that the ease of problem interruption on a digital facility, and the relative awkwardness on an analog, is very important. On the other hand, a great deal of program adjustment can be done on the analog computer which cannot be accomplished as well on the digital. I talked to a mathematician the other day who swears by* digital computers. To him the idea of going into a computer lab and twiddling a knob

*Not at!

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58 FACTS PROVE THE MC-5800 OBSOLETES EVERY OTHER ANALOG COMPUTER MADE

solves problems faster, more accurately, and at less cost!

The MC-5800 provides FASTER answers

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7. Complete control of all amplifiers, multipliers, dividers, and non-linear equipment at patchboard.

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The MC-5800 performs MORE ACCURATELY

10. Amplifiers provide lowest noise level output—less than one millivolt at unity gain.

11. Greatest distortion-free amplifier output—30 mils at ± 120 V—only 12 mils quiescent drain.

12. Lowest amplifier grid-current < 10^{-9} ampere.

13. Stable amplifier operation over the entire feedback range from zero to infinity.

14. Drift < 50 μv in 8 hours in summing mode.

15. Amplifier frequency response—flat to 10,000 cps and only 3 db down at 28 kc.

16. Only diode function generators utilizing resistors, potentiometers, and diodes of equal quality to those in computing networks.

17. Only diode function generators with individual hi-lo gain positions for *each* segment.

18. Lowest function generator drift < 5 mv/8 hrs.

19. Highest servo multiplier accuracy, ±0.008%.

20. Only fully shielded patch *bay* and patchboard.

21. All contacts in patching system gold-plated.

22. Highest performance electronic multiplier—flat to 10,000 cps and only 3 db down at 20 kc.

23. Only servo multipliers and resolvers with zero backlash gearing—maximum one part in 36,000.

24. DC tachometer feedback on all servos.

25. Dynamic servo error—less than 50 mv at one cps.

26. Lowest step-function overshoot—less than 1%.

27. EVERY SPECIFICATION IS GUARANTEED TO BE TRUE PERFORMANCE STANDARD—IN SUSTAINED OPERATION.

28. Highest sin-cos resolver accuracy ±0.03% peak-to-peak.

29. Power supplies eliminated from console—lowest, most stable operating temperatures—rise < 3°C.

30. Passive networks stabilized at < 1°C above room ambient—no oven required.

31. Servo-set pots can be set to 2 parts in 10,000.

32. Accuracy of computing networks at least 0.01%.

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The MC-5800 can be operated at LESS COST

34. Greatest available problem capacity per dollar—by 20%.

35. Least cost for future expansion.

36. Output tube filaments operate with DC bias for maximum life.

37. Centralized overload indication for quicker trouble-shooting.

38. Only computer with hermetically sealed transformers.

39. Choppers employ double-contacts in parallel for maximum life.

40. Plug-in relays and step switches throughout for least down time.

41. Plug-in dynamic components ease maintenance.

42. Quickest trouble-shooting by automatic problem check.

43. Costliest and best patching system for lowest programming cost thru maximum reliability of patchcord connections.

44. Choppers de-energized when computer in standby for max. life.

45. Separate power-supply venting minimizes room heat load.

46. Exclusive equipment-door packaging for free access and quick maintenance *without* shutdown.

47. Insulated patchboard prevents costly shorting accidents.

48. Sealed servo gear boxes for maximum reliability.

49. Fully transistorized ADRAC system with plug-in logic modules.

50. Available on lease basis as well as for purchase.

The MC-5800 can SOLVE MORE OF YOUR PROBLEMS

51. Exclusive dynamic memory makes automatic iterative solution of statistical or optimization problems a reality.

52. Dynamic memory + high-speed quick-reset rep-op provide practical approach to solution of simultaneous partial differential equations.

53. Exclusive bi-variable function generators can also be used as amplifiers, multipliers, or generators of single-variable functions.

54. More computer capacity per dollar means more solutions.

55. Solution of problems with up to 15 amplifiers in closed loops.

56. Starting with as few as ten amplifiers, at a cost of little more than the cheapest available computer, you can build to a complete computing center of unsurpassed performance.

57. Add-on capacity up to 134 amplifiers, 30 electronic multipliers, 18 diode function generators, 2 time-delay generators, 8 relays with amplifiers, 4 bi-variable function generators, 6 servos, 8 function switches—all field-expandable without mechanical rework or rewiring.

58. Add-on features include automatic problem check, integrator rate test, high-speed repetitive operation, dynamic memory, expanded-time base, compressed-time base, servo-set potentiometers, and ADRAC (Automatic Digital Recording and Control) system—all field expandable without mechanical rework or rewiring.

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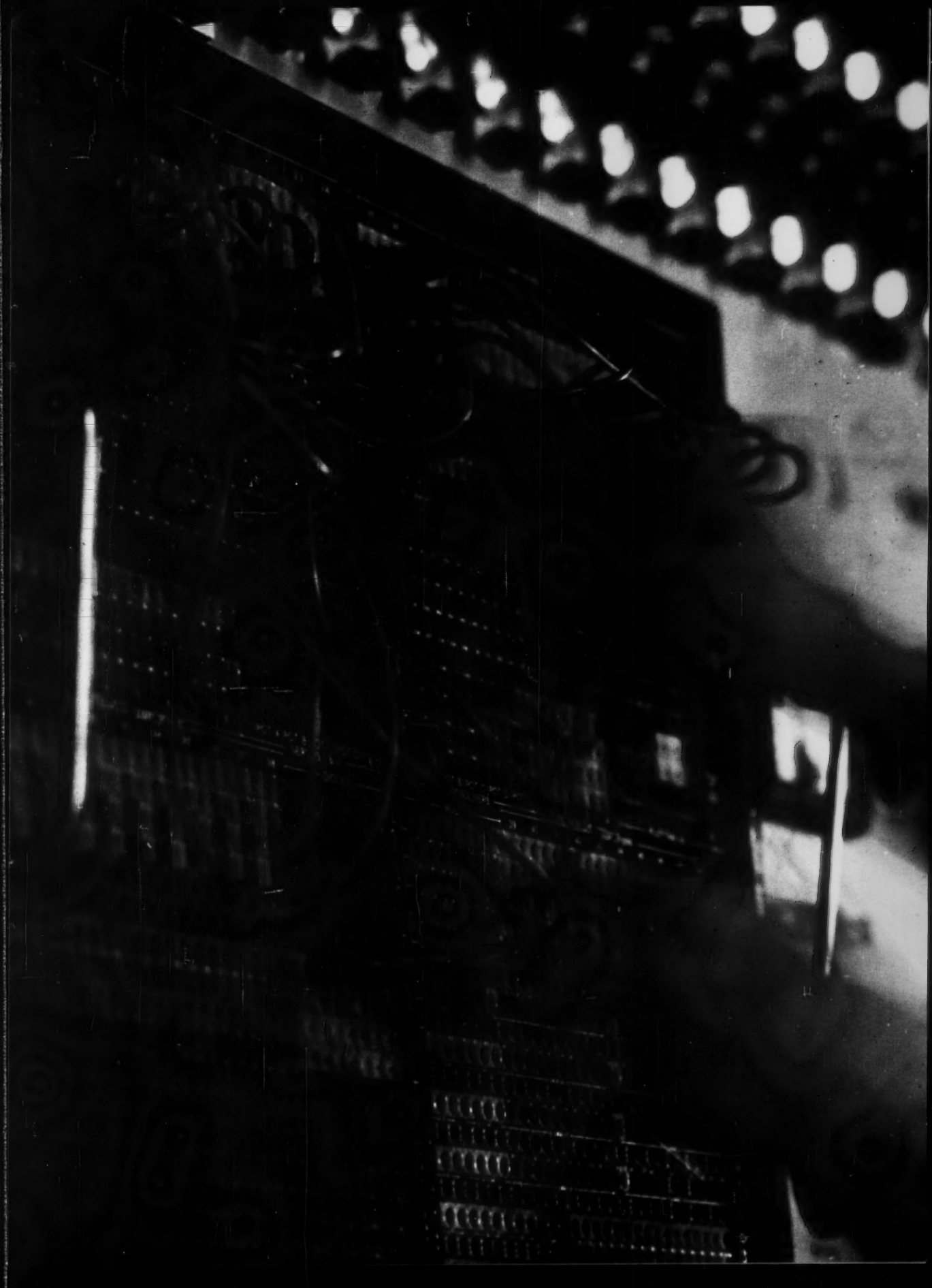

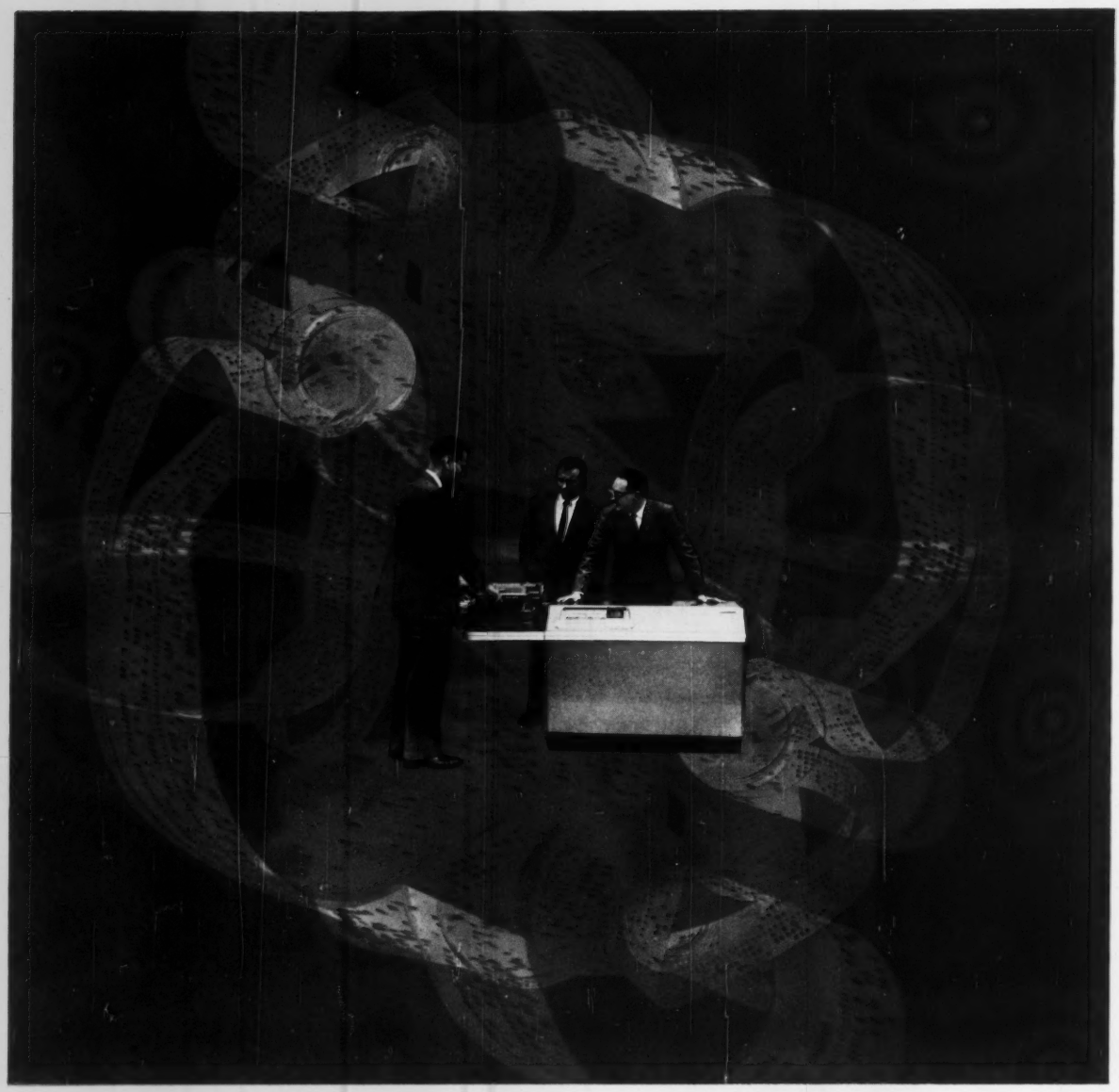

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Because the LGP-30 command structure and controls have been remarkably simplified, you require only minimum experience. You get complete format control...alpha-numeric input-output via keyboard or punched paper tape. No additional equipment is required for operation although, if desired, a high-speed photoelectric reader—with or without mechanical punch—is available.

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Royal Precision Corporation

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to see what the results look like is abhorrent; he feels that this is the result of lack of forethought and proper planning by the engineer! Well, in some areas it is simply impossible to predict what parameter variations are practical or suitable. So I think there is certainly a place for cut-and-try techniques, and the analog computer is particularly well suited to them.

"Is there going to be an eventual ease of program adjustment on a digital computer to give the engineer the immediate feedback that he needs for optimization of syntheses while he is standing by? The mathematician I talked to felt that if the engineer gets his results within a day, he should be very happy; I think the engineer wants them within a matter of seconds!

"What kind of man operates an analog computer? In my experience, he will be a systems analyst or an engineer with a broad feel for the physical realities of his problem, not a mathematician to whom the problem is an assemblage of differential equations. And the engineer should be free to interpret his results directly as obtained.

"Analog development should go in the direction of still more ease of manipulation—more automation. Not all of the automatic features now available inspire full confidence. I believe there is more to be done along these lines. New procedures ought to be cultivated.

"A fruitful field seems to be perturbation methods which lead to a combination of digital and analog operations, not in a simultaneous but rather a sequential operation. If a full-time solution of high accuracy is available from a digital computer, it would certainly be economical and practical to use an analog computer to study the effect of perturbations around this nominal solution. A typical case was first discussed by *Emery St. George* (formerly of MIT). The problem involved a ballistic missile and its perturbations due to windage, inaccuracies of the cut-off point etc. A followup of the digital study was conducted on an analog computer to discover trends. A new paper on the subject, presented at the Dallas National Simulation Conference last fall, has been published by Bush and Orlando of Cornell, and I recommend it highly."

Following Han's observations, *Irwin Pfeffer* introduced the next speaker, *Keith Uncapher* (Rand Corporation, Santa Monica, Calif.).

Uncapher on Digital Trend

"Within the spectrum of trends in simulation," Keith said, "I should like to cover a fairly narrow band—the direction in which the digital arts are going and why, and the implications for simulation.

"The current emphasis of the digital art is to bring about a new concept in machine design and fabrication which will result in fairly low-cost, very reliable devices with fast circuits and flexibility in design. Engineering techniques will be developed for the fabrication with relative ease of not only general-purpose computers but also special-purpose devices." The possible application of this new generation of computers to simulation is what brought Keith, a strictly digital man, to this meeting.

"The digital field," he said, "has adequate financial support, and has had it for a long time. This has pushed the digital art considerably faster than most people ever thought possible. Today, for example, the circuit designer faces a difficult fact of life: in being asked to design circuits which operate in the millimicrosecond region, he faces a real physical problem trying to assemble components. Since light travels essentially at the rate of one foot per millimicrosecond, the designer knows that if he is going to design a large system he *must* package the device in one or two cubic feet. This is a problem! He's not about to get around the difficulty with the hardware available at present.

"So, with the requirement for millimicrosecond speed it appears that the only way out is a new concept of design and packaging. A most promising design is the evaporation-deposition of thin films, which may be used for circuits which will operate in the required range. These circuits show promise because physically the components are one or two or three thousandths of an inch thick, and considerably less than a sixty-fourth of an inch long. Therefore, packaging several thousand such passive and active elements per cubic inch—hundreds of millions to the cubic foot—looks promising. Thus the transmission of digital signals in the milli-microsecond region may cease to be a problem.

"There are other payoffs which are extremely interesting; there is the possibility of using digital devices for simulation. This particular kind of fabrication of circuit elements lends itself extremely well to continuous automatic fabrication of incremental building blocks, and even large sections of digital devices, for example an entire adder. Ultimately the art shows promise of allowing the automatic fabrication of an entire machine. This is, of course, years off, but we'll get there!

"This technique also holds promise of allowing production of digital devices to describe the entire control process required to deposit large segments of a future digital computer or, in the limit, the entire digital device. This of course frees the designer of many problems he now faces using available components.

"The side effects of this kind of fabrication are extremely interesting. They promise low-cost elements, reliability beyond that expected now of even the more discrete circuit elements, and extremely flexible organization and construction.

"These techniques, coupled with the fact (which most of us realize) * that this is the age of discrete mathematical solutions rather than continuous**, would lead one to believe that there might be a more promising tool for simulation in the field of digital art. I believe this is true. And I think another attractive feature is that the research cost will not be borne by people interested in simulation. The real impetus behind construction of machines of this nature will come from the fields of business and scientific use where machines now available fit neither the problem nor the cost.

"In the future, from the standpoint of implied reliability and flexibility of design, it looks as though the digital field will offer much to simulation. There is, of course, the problem of getting man into the feedback loop, which is important to many simulators. I believe this will be solved in the digital field, because there is much pressure to develop mechanisms to permit intimate contact between man and his machine. Some of the promising techniques which come to mind are direct voice communication between man and machine. Also there will be quite elegant display devices which will help to close the man-machine loop.

"I would expect more effort in the digital field than in the analog for some time to come, because more dollars are available for research.

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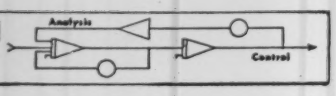
*Oh!

**or Ouch!



"I see a very promising tool for the field of simulation that will come about, not as a result of simulation per se, but because there is a requirement for millimicrosecond machines and a requirement for coupling the scientist to his machine which will have incidental payoff to simulation."

The next speaker was *Walter Karplus* (UCLA, Los Angeles, Calif.), whom Irwin introduced immediately after Keith's talk.

Karplus on Trends in Education and Field Problems

"I'd like to comment on two items on the general subject of trends," Walt began. "One of these is in engineering education. The other pertains to my own specialty, that of simulating field problems.

"As most of you know, the subject of computation, as now handled in most departments of engineering, is a highly specialized one; we have one sequence of courses in analog computing, another in digital. In the analog area, we usually have an introductory and then an advanced course on computer operation; finally a course restricted entirely to applications. Similarly, in the digital area we have courses on the computer, techniques, and applications. The reason for the dichotomy is twofold; on the faculty of a typical college there are usually specialists in analog techniques and specialists in digital techniques, all of whom began some years ago to carve out empires in their particular areas, and there is pressure from industry to provide specialists in each area. I suggest that perhaps the time has come to unify the presentation of computer material in the college curriculum.

"We might begin by having a senior course: an introduction to analog and digital techniques. This should be followed by a graduate course touching such subjects as simulation using both analog and digital techniques. We might have another course in a subject like data processing or the handling of telemetering data, again using both types of equipment. This might be followed up by extending computer techniques into other fields.

"If such a program is adopted, I believe its effect will be felt in industry as it will tend to break down the sharp division between the analog and digital groups now existing in many companies. Thus we would have a group of engineers adequately qualified to evaluate any given problem to determine just how it should be handled. This approach would also help in combined simulation, in that a person with a background in both areas could determine at what point one should switch from digital to analog and vice versa.

"As to the simulation of field problems, some months ago I addressed this group and discussed the Liebmann method of treating field problems—a method which is, to some extent, a blend of analog and digital techniques.* It employs a completely digitized finite difference approach to field problems. Both the space and time variables are approximated by finite difference expressions and the solution is obtained stepwise in time. On the other hand, the device is analog in that the data in the computer are continuous DC voltages measured at network nodes.

"Since that talk we've worked hard at UCLA (and there has been parallel effort in England) to generalize this technique, originally designed just for heat transfer problems, to handle problems of waves and beams. We have succeeded in designing a general-purpose computer for field problems—that is, one using plug-in connectors. A computer of this type is particularly useful for problems in which the field parameters vary with time or in which they are non-linear.

"Handling of time-varying or non-linear field problems has always been a tough one, on either analog or digital equipment. On analog the resistors or capacitors, or both, must be adjusted as the solution progresses. On a digital computer the program becomes even more complex. With machines of the type now being developed at UCLA and in England, such adjustments can be made more readily, although they still add to solution time."

Irwin next introduced *Floyd Steele* (Litton Industries, La Jolla, Calif.).

Steele on Trends in DDA's

"I'll confine my remarks to trends in digital differential analyzers as they might be applied to simulation," Floyd said.

"The actual state of the art today permits the development of a digital differential analyzer of desk-top size, having some 200 integrators. Such a device produced in economical quantities can be sold at a cost below $10,000, which permits its use at individual desks rather than in computing centers.

"The consideration of 200 to 1,000 integrators instead of, say, 20 or 30, begins to show a completely different speed balance between DDA's and other types of simulators. I think one of the things that people sometimes fail to notice is that the DDA is inherently a parallel machine in its mode of operation, whereas the general-purpose digital computer is basically serial. Such an observation at present leads to confusion, because the words parallel and serial are being pre-empted by custom to describe memories rather than processes. The parallel nature of the DDA computational process, as contrasted to that of the GP, is evident, however, by considering that in one minor machine cycle the DDA advances the entire computation by one increment, whereas the GP advances by only one step in the large number of steps necessary to make a similar advance. The DDA is thus an inherently faster process, within its proper field of application. Because the general-purpose computer utilizes a serial process, parallel memories have been resorted to at great cost to make up for the speed deficiency. Because the DDA is computationally a parallel machine and has an excess of speed, it can utilize a serial memory to achieve great economy in cost. This low cost, as compared to the GP, is achieved while maintaining equality in speed. If 200 to 1,000 integrators are used instead of 20, the time to advance the computation by one increment still remains unchanged. Thus the relative speed has advanced 10 to 50 times, since the GP normally requires a time in proportion to problem size to advance by an increment. At this point the DDA generally will be found faster than the high-speed GP's.

"When non-linear equations requiring 200 to 1,000 integrators are involved, it becomes difficult to appraise analog speeds. The growth of error will often render analog solutions meaningless. Results can be obtained only in conjunction with a digital computer, for example by running a wide range of digital solutions, then matching them by making analog adjustments. The analog can thus serve as an enormously expensive interpolator. It is doubtful whether this represents an economic application.

"Present-day DDA approaches have not successfully exploited the low-price market for which the serial memory embodiment is suited. Sev-

*See *Newsletter*, February 1959.

SPEAKING WITH EASE®

An up-to-the-minute report on computer technology prepared by the **Beckman/Berkeley** *engineering staff*

A Method of Testing Operational Amplifiers

What must be checked to insure performance?

Four characteristics are critical.

Balance – how much offset exists? How rapidly is it drifting?

Open-loop gain – what is the gain of the dc-coupled stages and the gain of the chopper stabilized section?

Power – will it deliver enough current to drive imposed loads?

Grid current – how much grid current is flowing to the summing junction?

If you get favorable answers to these questions you can be almost certain that the amplifier will perform properly.

The General Approach to Testing

It should be possible to perform tests quickly, without removing amplifiers from the computer and preferably without disturbing patchboard connections. Most important, the amplifier should not be subjected to the thermal shock of removing power and re-energizing, a shock which may modify the very characteristics under test. In addition, the procedure should be one that can be mastered by technicians comparatively unfamiliar with computer theory.

With these considerations in mind, EASE engineers have developed the standard test box shown in Figure 1. This unit will test all the characteristics noted above except grid current. Grid current is detected by an over-all computer test known as the "integrator check" mode of operation.

Testing and Adjusting Balance

If you can measure offset at the summing junction to within 10 μv you will be able to hold total offset well within 30 μv, thus insuring adequate integrating accuracy. Moreover, with accurate tests at regular intervals you will be able to estimate the rate of drift, thus detecting and correcting amplifiers that might prove troublesome.

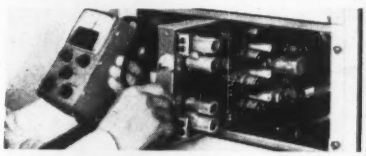


Figure 1. The tester in operation.

The circuit used to test EASE amplifiers appears in Figure 2. The amplifier is placed in a closed loop so as to duplicate the conditions of actual operation as nearly as possible. The quantity metered (amplifier output voltage) bears a precise mathematical relation to the grid voltage – a 1001 to 1 relation, as the equations demonstrate. Thus by metering the output to within 10 mv we can accurately detect summing junction offsets as small as 10 μv. Notice that the measurement will not be affected by any change in open-loop gain except a drastic loss of amplifying power.

Balancing a battery of operational amplifiers (50, 100 or 150 amplifiers) can be extremely time-consuming unless the metered offset is immediately responsive to the balancing potentiometer. For this reason the balancing pot in EASE amplifiers has been placed in the stabilizing amplifier section where any adjustment causes an immediate change in output voltage.

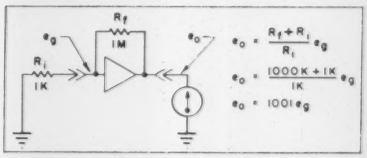


Figure 2. Setup for testing balance. e_o is metered to within 10 mv, thus measuring e_g to within 10 μv.

Testing Open-loop Gain

It should be possible to check the gain of both the dc-coupled section and the chopper-stabilized section. The dc section is tested using the set-up diagrammed in Figure 3. Provided we measure actual open-loop gain (summing junction to output), a test at a single frequency is sufficient. This is because the *shape* of the frequency response curve does not change appreciably as tubes become weaker; the gain declines in the same proportion at all frequencies.

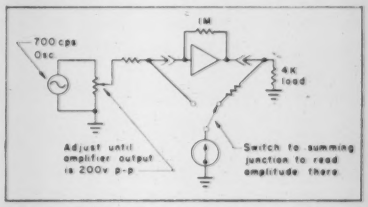


Figure 3. Circuit for detecting open-loop gain of dc-coupled section and load current capability.

The stabilizing amplifier, having no gain at 700 cps, must be checked in some other way. The method used is shown in Figure 4. Pressing the pushbutton injects a pulse of known amplitude. A flash from the overload neon shows that the output pulse is sufficiently strong to indicate adequate gain.

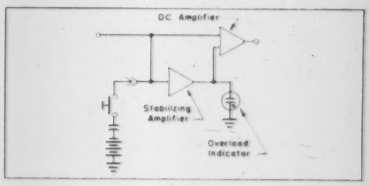


Figure 4. Setup for testing gain of stabilizing amplifier and overload alarm.

Power Test

Load current capability is checked at the same time as the gain of the dc amplifier. The amplifier is required to drive the 4000-ohm load shown in Figure 3, a load equivalent to seven 30K pots.

All the above tests can be performed in an average of 15 to 30 seconds per amplifier. For further details write for data on the EASE 1148 amplifier.

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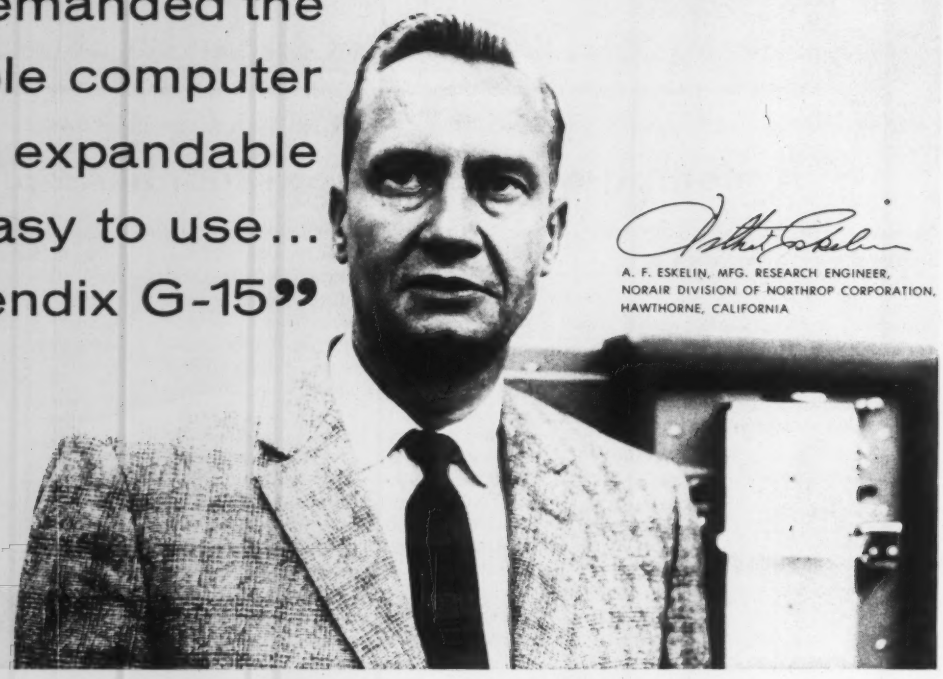

A. F. ESKELIN, MFG. RESEARCH ENGINEER, NORAIR DIVISION OF NORTHROP CORPORATION, HAWTHORNE, CALIFORNIA

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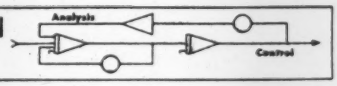

eral developments using parallel memories have been undertaken. This represents a case of mechanizing a parallel process in a parallel memory.

"Each integrator is made up entirely of sets of flip-flops, or alternately uses individual re-circulating memories. This leads to a fast computer for which, unfortunately, there is little economic use, especially since the hardware count increases enormously. A problem of intermediate size might require on the order of 100,000 semi-conductors for its solution. Parallel-memory differential analyzers are generally to be shunned as a development because the apparent applications, if carefully considered, can nearly always be reorganized to do without the parallel memory machine. In fact, I know of no valid applications, and would appreciate hearing of any.

"There is another class of machines that is half-way between the incremental and the numerical—those that use an increment in the independent variable that is represented by a number of several bits rather than by a single bit. One can carry this to the complete numerical increment, and have a peculiar kind of cross between the general-purpose and the differential analyzer processes. Again, it turns out that this speedup does not appear warranted in most applications. The cost and complexity seem to increase more rapidly than the utility.

"In many cases where the higher speeds appear to be needed, resolution has been confused with accuracy—a misunderstanding which has plagued the DDA both when applied to some simulation applications and when pronounced unsuitable for others. A great loss of speed is often occasioned by scaling the DDA to high accuracy in order to get 'smooth' results when low accuracy is acceptable. Smoothing can usually be done externally. As an example, pilot trainers do not need accuracies above about one part in 16 in most loops. At this accuracy a serial memory DDA has an excess of speed. Unfortunately, this application has often been investigated at accuracies of one part in several thousand, an artificial circumstance which excludes the low-priced DDA application."

Leondes on Training Devices

Pfeffer: Our last speaker is *Cornelius Leondes* of UCLA.

Leondes: "I want to talk rather broadly about trends in simulation usage and present my own opinions on training devices in system and component design, on system evalution, and anthropomorphic systems.

"There are several types of training devices—combat information center devices, flight trainers, and others. Initially analog computers (AC rather than DC) were used for flight trainers. With an analog computer you are more or less committed to the simulation of a particular type of system—e.g., an F9F and no other. This leads naturally to the consideration of digital computers for training devices because all you have to do to the computer to change the plane being simulated is to slip in another program. By contrast, the analog calls for a change in the computer. **So in the area of training devices my feeling is that probably digital computers have the edge.**

"In the area of system design the first problem is component design. The component can be designed in other than real time either on the digital or the analog computer, and the hardware can be checked out dynamically before inclusion in the system in a real-time closed-loop system simulation.

"In system evaluation, we have the same sequence of possible combinations. I don't think that in the areas of component and system design and system evaluation either analog or digital computers can be signed out as having the edge.

"An example of the power of analog computers may be found in their use for system synthesis.

"Recently I've been looking at adaptive systems, very non-linear devices. We have spent some months trying to evolve theories for the conception of adaptive systems and for ways of showing that one adaptive system is better than another. We have on campus a Bendix G-15 and an IBM 709, and we have been conducting our studies in the main with these. In the past few weeks we have had available an analog computer, and by playing with knobs and trying different setups we have developed whole new thought areas. **I would say we have accelerated our program of research by several months at least. If we had gone on for several years without using an analog device these months would have been wasted, there's no question about it.** You

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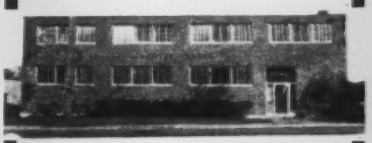

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* See page 1221, July '58 Issue of Instruments & Automation.

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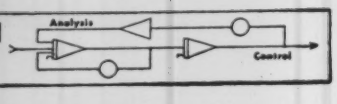


just can't plan everything. When you're studying systems like these you simply can't have everything well thought out in advance because there are lots of things you discover when you go off on tangents. And you *want* to go off on tangents! Of course I feel strongly, but until something is done with digital devices to make them comparable to analog ones, I think that analog devices hold a strong edge when it comes to studying problems in areas like the one I have referred to. This, after all, is the direction in which we're moving in control system synthesis. We've beaten linear system synthesis pretty much to death. Now we are forced to move into areas involving analysis and synthesis of non-linear systems.

"Another area that I wish to mention is the use of simulators in anthropomorphic systems—systems having human characteristics. In some weapon systems we want to replace the human operator—and we want to make decisions rapidly. The more routine decisions, which take place at a very rapid pace, call for the replacement of human operators. Probably here the edge is held by digital devices. Suppose we have a number of observations on an array of objects and they can be correlated. If the information is gathered in a systematic manner and can be represented by an array of symbols we can take the human operator out of the system and insert a device or devices which can make the necessary decisions much more rapidly and reliably.

"I also wish to mention these new devices called *perceptrons*, which are used for system evaluation where the system we're trying to evaluate is the human himself. From experiments on such machines we might, in the future, glean information which will put us in a stronger position when it comes to treating people with mental ills."

* * *

Irwin Pfeffer opened the question period with one directed to *Hans Meissinger*: "I think you indicated that you expect an increase in post-flight evaluation using simulation. How do we prepare for this? Should we strive for a general program, either analog or digital, capable of simulating any system down to the last detail? Or should we try to tailor each post flight evaluation towards a particular case, thereby risking delay because we have to do the programming after the fact?"

"My own opinion is that we should shy away from the excessive complexity of large problem mechanization," Hans answered. "I don't think an analog computer setup involving more than a couple of hundred amplifiers is warranted, no matter how complex a task you want to simulate. I feel that some of the techniques which have been discussed recently for tying in perhaps a thousand or more amplifiers are not going to prove practical. I'm sure more complex jobs can be handled on the digital rather than on the analog computer. I would rather risk the delay of tailored programming than the delay involved in not getting a giant computer to work."

"In San Francisco," Irwin pointed out, "A paper was presented by *Hintze* in which he described a simulator to be used not only for post-flight evaluation, but also for in-flight control."

Dr. L. D. Kovach (Douglas Aircraft, El Segundo, Calif.) remarked, "I think the real trend is towards more faithful simulation, and this does not lead to simple systems, discrete systems, few amplifiers, nor small installations. If we're going to have more faithful simulation we're going to have to face the large installations. I'm thinking of the important non-linear effects that are all around us, and the continuity which is also in nature."

Karplus: "I would like to make a point. Getting the problem on the computer tends to become the end of the thinking phase of a project. I think this is a dangerous trend for scientific development. The increasing reliance on simulators brings with it a corresponding sacrifice of analytic ability."

Leondes: "I'd like to ask Dr. Kovach a question. Can you give us some examples in which the simulation was not faithful enough?"

Kovach: "Yes, I think I can. Several failures in missiles have been analyzed recently, and the failures have stemmed from inaccurate analysis of non-linear effects."

"Was it because the computers were not faithful enough, or because the mathematical model was not faithful enough?"

"I think both. I think the reason that our mathematical model was not faithful enough is that we've been limited in the actual equipment. We do not have 300 multipliers and a thousand amplifiers!"

Ed DeLand (Rand Corporation, Santa Monica, Calif.): "I'd like to ask Mr. Uncapher if it will be possible five years from now to tell a computer to design another special-purpose computer and then in a half hour walk away with a completely designed new machine ready to go?"

Keith: "By far the most difficult aspect of this problem is the design. That is why it was stated that a present-day computer can *aid* in the design, and this is about all I see for quite a while."

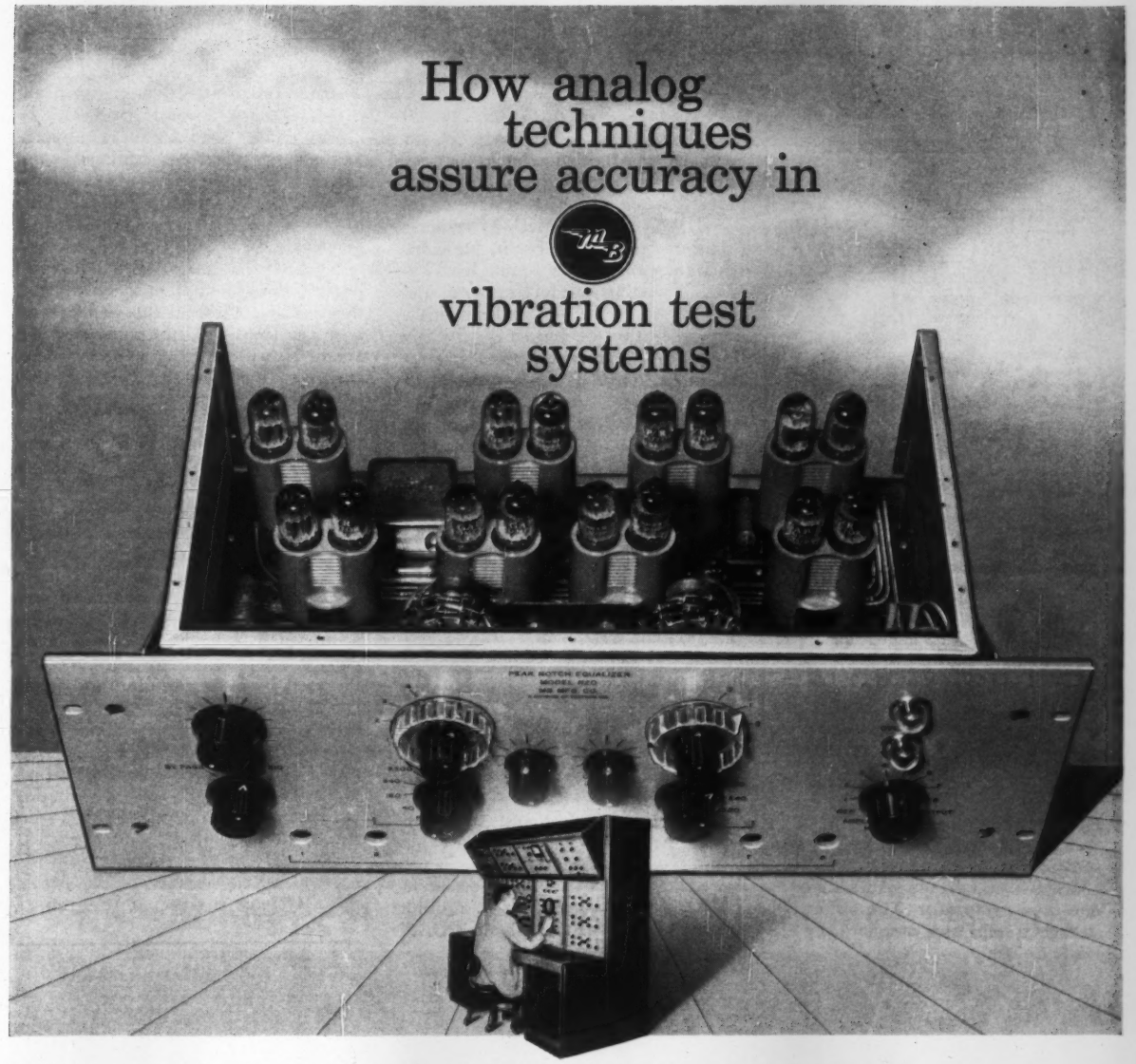
Ed: "I should like to simply give the digital computer a set of differential equations and have it construct from these equations a special-purpose computer which I can then install in my plant to control a process."

George Bekey (Space Technology Laboratories, Los Angeles 45, Calif.): "It seems to me that there are two good reasons for using an analog computer. One is to solve the problem which at present cannot be handled as efficiently, as well, or as inexpensively on a digital computer. This is gradually becoming less important as digital machines advance. *More important, the analog computer is an insight accelerator.* My personal feeling is that at STL this is really the only valid reason for analog studies. We certainly do not use the analog computer to get numerical results. This raises the question of why you would want to do a thousand-amplifier study as Dr. Kovach mentioned. If you do this you will completely negate the insight function. My feeling is that the surest way to wipe out the analog computing art altogether is to generate thousand-amplifier installations. To use an analog computer to gain insight into the operation of a physical system, we should limit ourselves to smaller problems.

"Another comment: Keith Uncapher said that we are tending in the direction of discrete mathematics. What has happened since our undergraduate days? It wasn't so long ago that the world was linear, free of disturbing influences, and continuous. Now it is not only non-linear and noisy; it's no longer continuous. It is discrete. Of course, there is some justification for this—as we look more closely at the structure of matter we see crystals which are discrete entities, as are the molecules. But when did this happen?"

Keith: "I guess it has always been. I can't think of anything more discrete than the charge on an electron. It is a matter of recognizing the dis-

How analog techniques assure accuracy in MB vibration test systems



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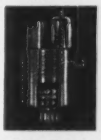

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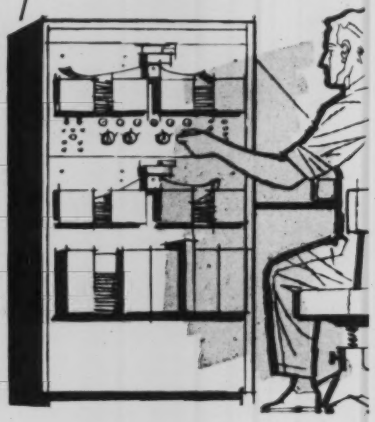

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creteness, and we are getting more perceptive."

Bekey: "The analog then is really the gross-look computer."

Harold Ehlers (Autonetics, Downey, Calif.) said he'd like to give a summary of experiences at Autonetics on the DDA versus the analog computer: "When we set up programs on our DDA (the MADDIDA) typical of those which we solve in the area of flight control, we found that because the DDA used integrators for scaling, integration, multiplication and generation of functions, the 50-integrator MADDIDA had insufficient capacity. It was equivalent to a 20-integrator analog computer. Even with expert programmers we were not able to approach the speed of the analog. A typical trajectory problem requiring one minute on the analog took 60 minutes on the DDA. Of course, the MADDIDA is an old machine, but later checks in the industry, with particular problems, disclosed that for comparable accuracy the time involved for the DDA was substantially greater than for the analog. In addition, the parameters on the analog were more amenable to adjustment."

Abbott Levine (NOL, Corona, Calif.): "There seems to be an impression that there is a basic speed limitation on the DDA. Of course this isn't true. If you double the drum rate—i.e., the clock rate, you double the speed of the computation on the DDA, so one could easily design a DDA to be thousand or a million times the speed of the current DDA."

Information (Without Theory)

Your Editor was invited by Daystrom Systems to participate in a panel discussion of the systems approach to process control as opposed to control by the application of standard control components. This session took place on July 20th in Ensenada, Mexico, and kicked off an intensive two-week training program for new marketing personnel.

Chal Jones, a charter member of the original Western Simulation Council and now General Manager of Daystrom Systems Division, and *Thomas Hudson*, Systems Coordinator, and this writer contributed to the defense of the systems concept. In the component applications camp were *Manny Otis*, Chief, Systems* Engineering and Systems Coordinators *Jim Burr* and *Martin Lyford*. The discussion was moderated by *John Palmer*, Marketing Manager.

After it was agreed—more or less—that a systems engineer is one who considers the dynamics of an entire process, including all of the cross-coupling and feedback effects, while an applications engineer considers the application of standard controllers to control individual units of the process, the discussion really got spirited.

So much has been written in support of the systems approach of late that I will not repeat the well-known and sometimes valid arguments in its behalf. I will however express some surprise (and—as one who in the past sold and installed, and later designed "standard controllers'—a little nostalgia) at the case for the opposition.

The systems approach requires very specialized talent, which will probably be expensive, and possibly special-purpose equipment which may have limited application if the process changes. And in many cases proprietary information may be compromised. Unless the process is complex, non-linear, or strongly influenced by cross-coupling and feedback loops it might be more economically "regulated" by standard components which can be installed by plant personnel and readjusted or used elsewhere if the process changes.

But if the process is tricky, the specifications on the product critical, or the cost of processing high with respect to the raw material, better put a systems engineer on the job.

He Went—Back!

Our friend of long standing, *Ted Kusto*, to Computer Systems, Inc. (formerly Mid-Century Instrumatic) as Director of Research to head up the company's development program for analog computers and simulators.

Computer Events

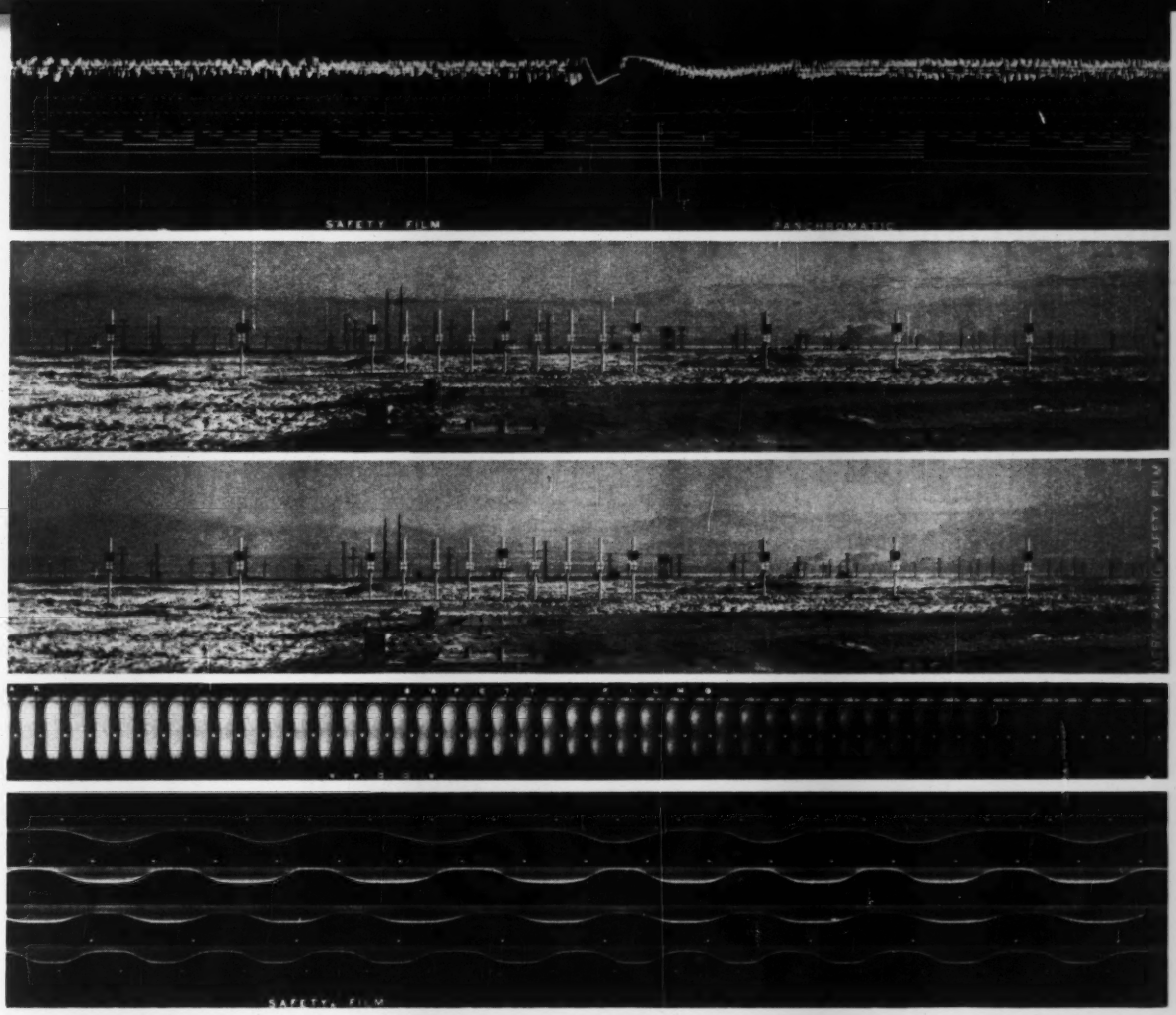
Central Simulation Council

Date: October 1959
Place: McDonnell Aircraft Co., St. Louis, Missouri
Subject: "Computer Environment"

Eastern Simulation Council

Date: October 19, 1959
Place: Princeton Computation Center, Electronic Associates, Inc., Princeton, N. J.
Topic: Unusual Applications of Analog Computers

*Still Chief *Systems* Eng., Manny?



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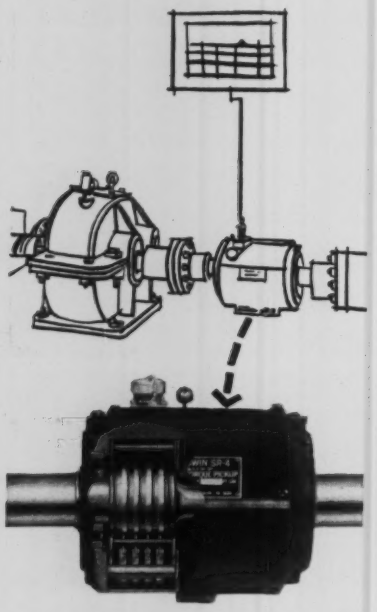

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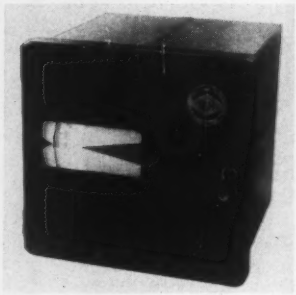

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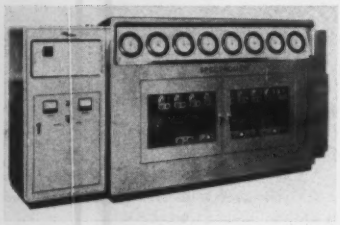

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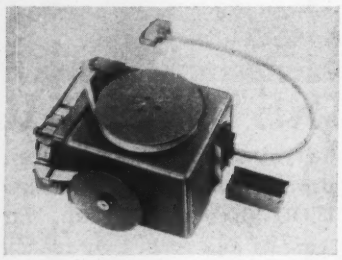

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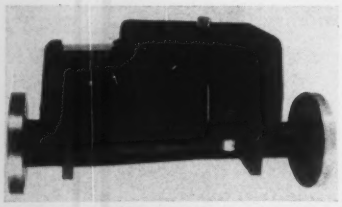

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New Model 3611 MPTX-50 Armored Transmitting Rotameter features straight-thru flow, completely-faithful magnetic float-position converter and indicator, purged guide cartridges, heating or cooling jackets, pneumatic or electric transmission. Ideal for difficult flow measuring problems.—Bulletin 170 gives details. —*Brooks Rotameter Co., P. O. Box 432, Lansdale, Penna.*

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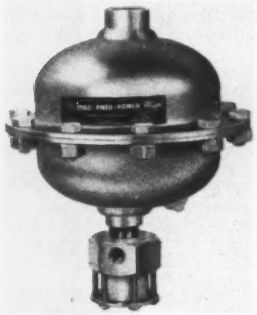

pheres, assures completely automatic condensate discharge by snap-action opening and closing, even at very low pressures. Pressure range is 10-200 psig.—*Hankison Corp., College & Pike, Canonsburg, Penna.*

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PATENT #2,885,143

DUO-SEAL® VACUUM PUMP

TWO-STAGE CONSTRUCTION

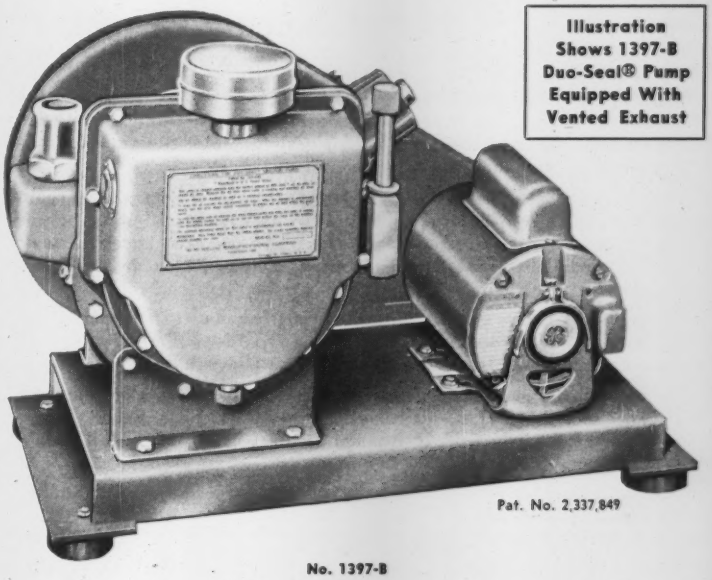

Illustration Shows 1397-B Duo-Seal® Pump Equipped With Vented Exhaust

Pat. No. 2,337,849

No. 1397-B

VENTED-EXHAUST

Removes Vapors Speedily and Effectively

★ Eliminates Traps or Oil Separators ★ Lessens Pumpdown Time

★ Reduces Number of Oil Changes

1397B. DUO-SEAL VACUUM PUMP, Motor Driven. For 115 Volts, 60 Cycles, A.C. Each, $645.00

1397C. DUO-SEAL VACUUM PUMP, Motor Driven. For 230 Volts, 60 Cycles, A.C. Each, $645.00

1397D. DUO-SEAL VACUUM PUMP, Motor Driven. For 115 Volts, D.C. Each, $749.00

A belt guard is included with the mounted pumps.

1397. DUO-SEAL VACUUM PUMP, Unmounted. With pulley, but without motor, belt or base. Each, $525.00

Pump Revolutions - 300 RPM
Motor - ¾ HP - 1725 RPM
Tubing Required - 1⅛-inch I.d.
Over-all Dimensions of Mounted Pump 25⅝ x 14¾ x 18¾ inches high
Belt-tightening Provision
Extra Supply of Duo-Seal Oil

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DIVISION OF W. M. WELCH MANUFACTURING COMPANY

ESTABLISHED 1880

1515 Sedgwick Street, Dept. B Chicago 10, Illinois, U.S.A.

Manufacturers of Scientific Instruments and Laboratory Apparatus

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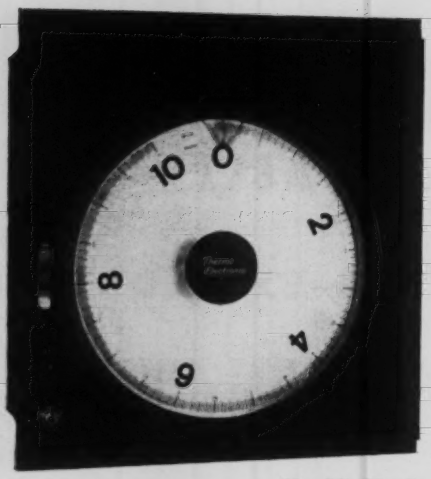

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These new potentiometer and bridge type indicators give you full 34″ scale readability at a distance. Within seconds, you can check accurately any one of several hundred sensing elements connected through multi-point switching systems. The instrument will automatically indicate any variable, convertible to DC potential, current, or resistance.

The heart of the indicator is the exclusive Thermo Electronic high-gain amplifier, which couples exceptional stability (±1 microvolt) with extreme sensitivity. It will maintain operating characteristics, even under the most adverse conditions. This guarantees consistent measurement in your processing.

Optional two or three position control is available and up to 6 alarm contacts are provided. Up or down scale fail-safe action guards your costly processing equipment in case of transducer, component or power failure.

The potentiometer indicator is standardized semi-automatically using full amplifier sensitivity. Full scale balancing speed—5 seconds. Range changes are easily made in the field. Instrument accuracy is ±0.25% of full scale—sensitivity is ±0.125%.

No matter what your measuring needs, you can best meet them with Thermo Electronic Instruments.

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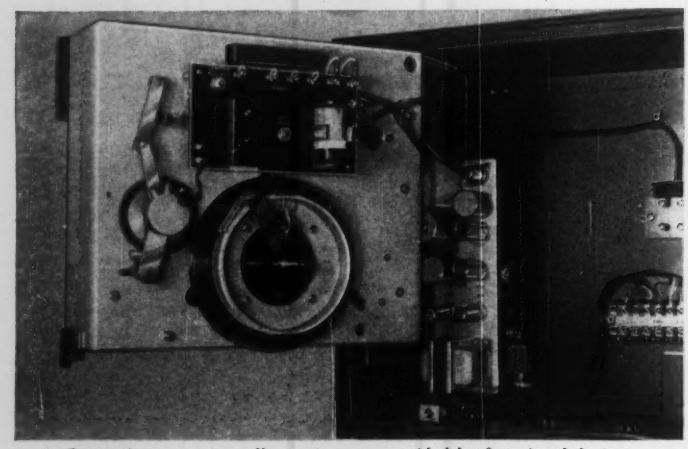

Convenient access to all components provided by functional design.

Thermo Electric CO., INC. SADDLE BROOK, NEW JERSEY

In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ontario

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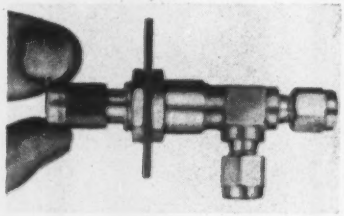
NEW INSTRUMENTS

METERING VALVE

New Metering Valve, featuring a 40-pitch thread and micrometric fine-flow control in the 0 to 4000 cc/min air-flow range, for gas analysis, sampling lines, research-lab, spectro-



graphic and chromatographic work, etc., operates by turning the knurled cap. Ten full turns open the valve to maximum flow.—*Nuclear Products Co.*, 15635 *Saranac Rd.*, *Cleveland* 10, *Ohio.*

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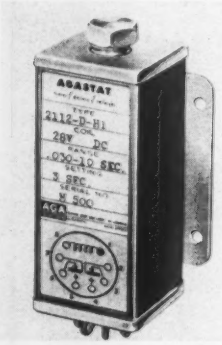
TIME DELAY RELAY

New miniature Time Delay Relay meeting military environmental specs and aircraft requirements is unaffected by voltage variations, and



features easily-adjusted timing ranges to a time-setting as low as 30 msec with a repeat accuracy of 5%.—Bulletin SM-2 contains details.—*AGA Div., Elastic Stop Nut Corp. of America*, 1027 *Newark Ave.*, *Elizabeth* 3, *N. J.*

CIRCLE 187 ON READER-SERVICE CARD

REFLUX ANALOG COMPUTER

New FRAC (Fractionator Reflux Analog Computer) Reflux Computer Controller, manufactured and marketed on license from Phillips Petroleum Co., uses standard electric and pneumatic instrument components, for determining and controlling internal reflux flow rate. Two variations are available. One is with a fixed-range, the other with an adjustable-range thermocouple-to-pressure transmitter.—*Minneapolis-Honeywell Regulator Co., Brown Instruments Div., Wayne and Windrim Aves., Phila* 44, *Pa.*

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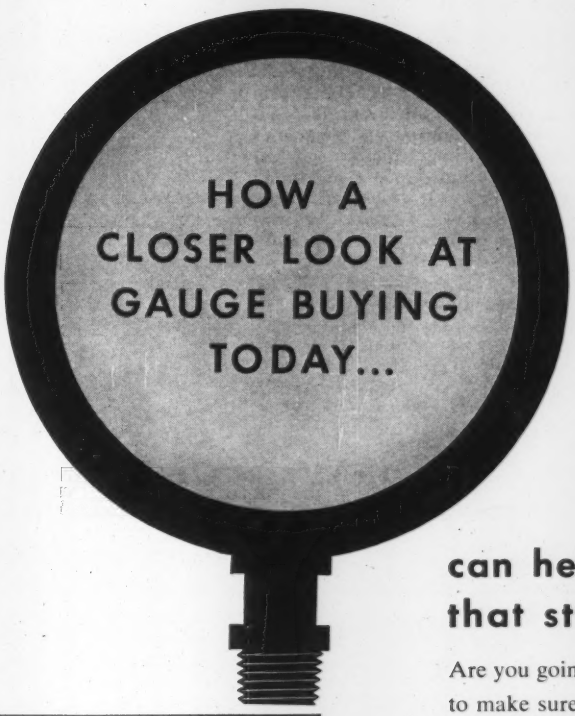

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Are you going to a higher price on gauges in order to make sure of gauge reliability? "Over-gauging" to get long life? It will pay to take a closer look at the size, flexibility, and high standards of accuracy of the United States Gauge line. At USG you can choose from over 50,000 standard indicating dial pressure gauges. Thousands of choices in case styles, sizes, materials, and in gauge components. Thousands of specials, too! Not only can you pinpoint your *reliability factor*, you can pinpoint your *price* for 99% of your gauge needs . . . from one line! It's easy to check . . . just call your USG distributor for your next gauge requirement. See the Yellow Pages, or write for catalogs and name of your distributor.

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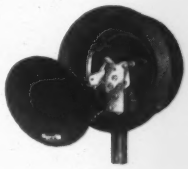
PICK Ni-Span "C" low pressure elements for exceptional thermal stability.

PICK Supergauge® for long life, accuracy to 0.5%.



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ADAMS FACT FILE #3

INSTRUMENT AIR

Clean Dry Air Supply Will Reduce Production Down-Time . . . Instrument Maintenance . . .

Wet, dirty compressed air has no place in the process industries. In instrument air supply lines it can cause havoc. Whether it be motor air in a control circuit or supply air to the control panel, absolutely clean dry air is vital. Moisture elimination is the major consideration in providing suitable air for instrument and control systems.

Since most plant compressors in use today are oil lubricated, a finite amount of oil is present with the water vapor in the discharge. This carry-over condenses as an oil-water emulsion which often causes serious fouling of instrument components. To eliminate this oil-moisture condensate in the air lines, it is necessary to remove it before it reaches the distribution system. This is done by cooling the air before the receiver. It is advisable to cool well below the ambient conditions to provide the lowest possible humidity at the instrument panel or control units.

Two Stage System Design for Economy

The ideal method to achieve high quality air is a two-step operation.

1—An Adams Aftercooler . . . providing 2° F. cooling . . . and Cyclone Separator installed between the compressor and receiver to remove the bulk of moisture carry-over.

2 — A chemical dryer installed down stream to provide the polishing action necessary for the desired minimum humidity.

Thus, the bulk of water . . . 90% . . . is removed by the Aftercooler-Separator using plant water for cooling. A minimum moisture load is then left to be removed by more expensive methods. Under normal circumstances, all of the oil present in the compressor discharge will be removed in the Aftercooler-Separator. Fouling of the chemical unit is then virtually eliminated.

Poro-Stone Air Filter at Panel Provides Dirt-Free Control Air . . .

In spite of the efficiency of the Adams Aftercooler and Separator, there still will be some dust and dirt present in the instrument air system. That's why it is advisable to install an Adams Poro-Stone Air Filter in the line just before the control panel.

Separation by the Adams unit is in two stages — centrifugal and diffusion. Centrifugal force throws the foreign matter to the walls of the filter body where it is trapped in slots and drained. Remaining particulate matter is removed as the air passes through the pores of the Poro-Stone element.

This final protection for your instruments will minimize control system failures and process down-time. Instrument maintenance will be sharply reduced.

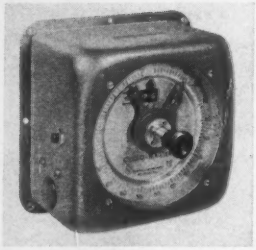
Literature Will Help Air System Design

For further information on how the complete line of Adams air equipment can help you provide a foolproof instrument air supply, write today for your copy of Bulletin No. 712 on Aftercoolers and Separators and Bulletin No. 117 on Poro-Stone Air Filters to the R. P. Adams Company, Inc., 265 East Park Drive, Buffalo 17, New York.

CIRCLE 85 ON READER-SERVICE CARD

RECYCLING CONTROLLER

New Cyclo-Master Recycling Conroller offers one-count switching, one-cycle switching, or differential (add-and-subtract) counting and switching for liquid metering control; interval indication in high-production count; forward-and-reverse control with preset limits; control of motors, valves, pumps, relays and signals; size control for wound reels or spools; container filling; etc. Counts at speeds up to 1000 counts/min.—Bulletin 700 gives details.—*Counter and Control Corp.*, 4503 *West Brown Deer Rd., Milwaukee* 18, *Wis.*



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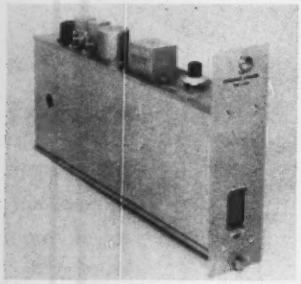
FM REPRODUCE AMPLIFIER



New FM Reproduce Amplifier, Model 1-143A, for use with magnetic-tape recorders, features an improved frequency pulse discriminator, and solid-state components, except for a low-noise vacuum tube used as the input linear amplifier. Signal output is one volt rms for ±40% deviation.—*Consolidated Electrodynamics Corp.*, 360 *Sierra Madre Villa, Pasadena, Calif.*

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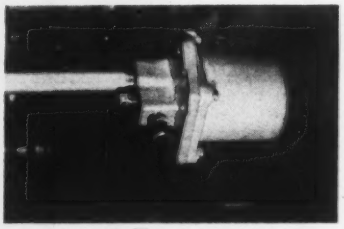
RESISTANCE PRESSURE DETECTORS

New Resistance Pressure Detector, Model 328 RPD, for measuring gas-, fluid- or vapor-pressures in combination with Omniguard Monitor, converts pressure directly to an electrical resistance. Ranges are from low pressures, measured in "HG to pressures of 3000 psig. It is normally mounted in a pressure detector head for protection.—*Instrument Div., Thomas A. Edison Industries, of McGraw-Edison Co., West Orange, N. J.*



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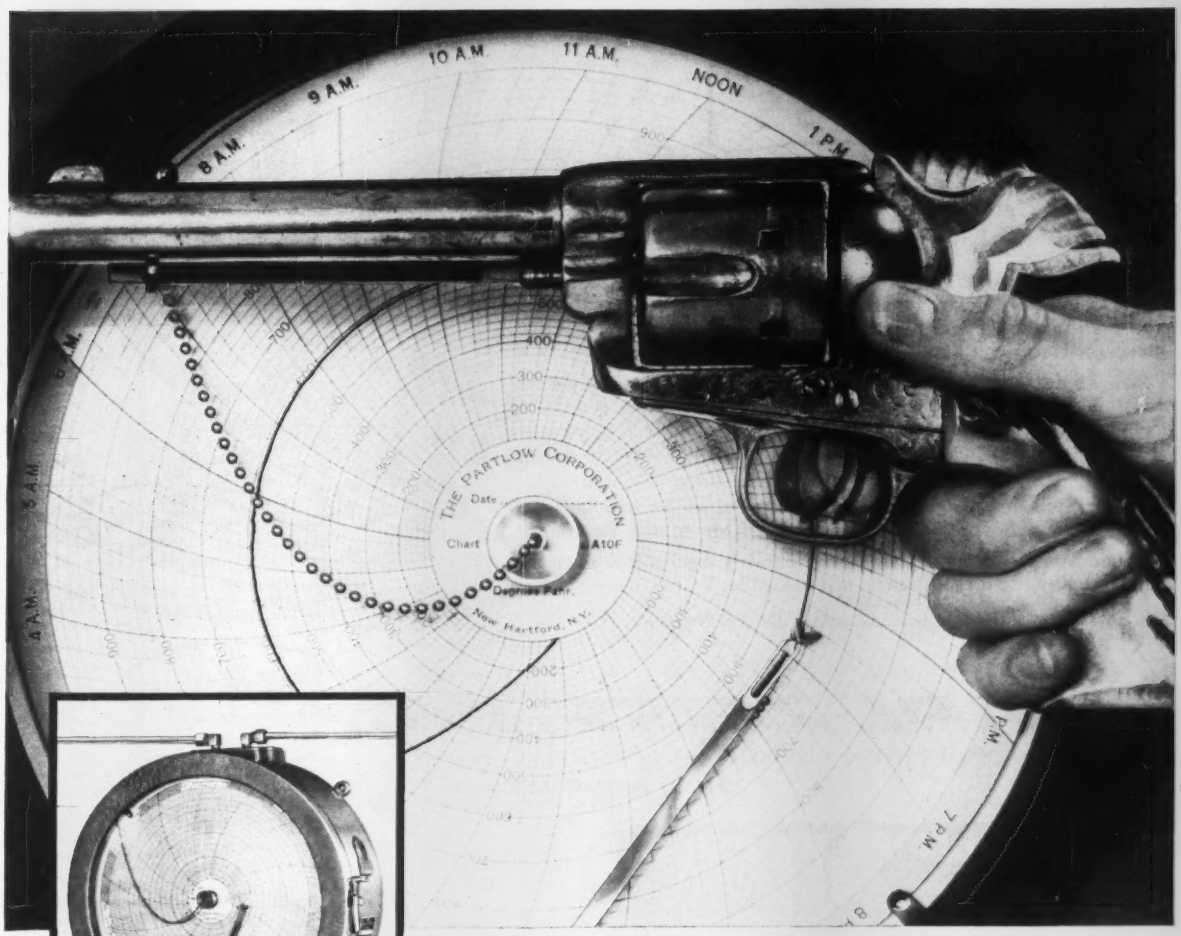

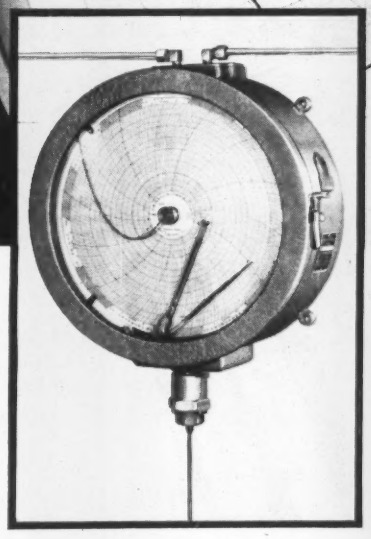

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- The illumination of slit monochromators and repeat type printers.
- The testing of materials (as in fade testing).
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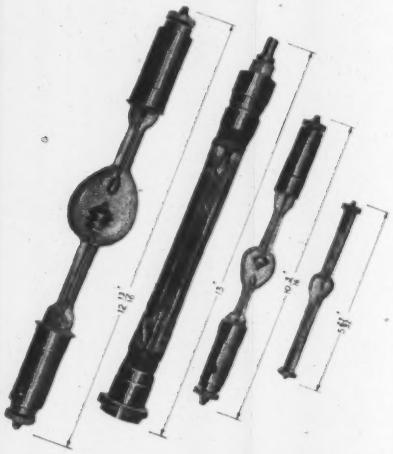

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Arc size 1·2 x 2·4 to 2·1 x 4·2 MM

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product index

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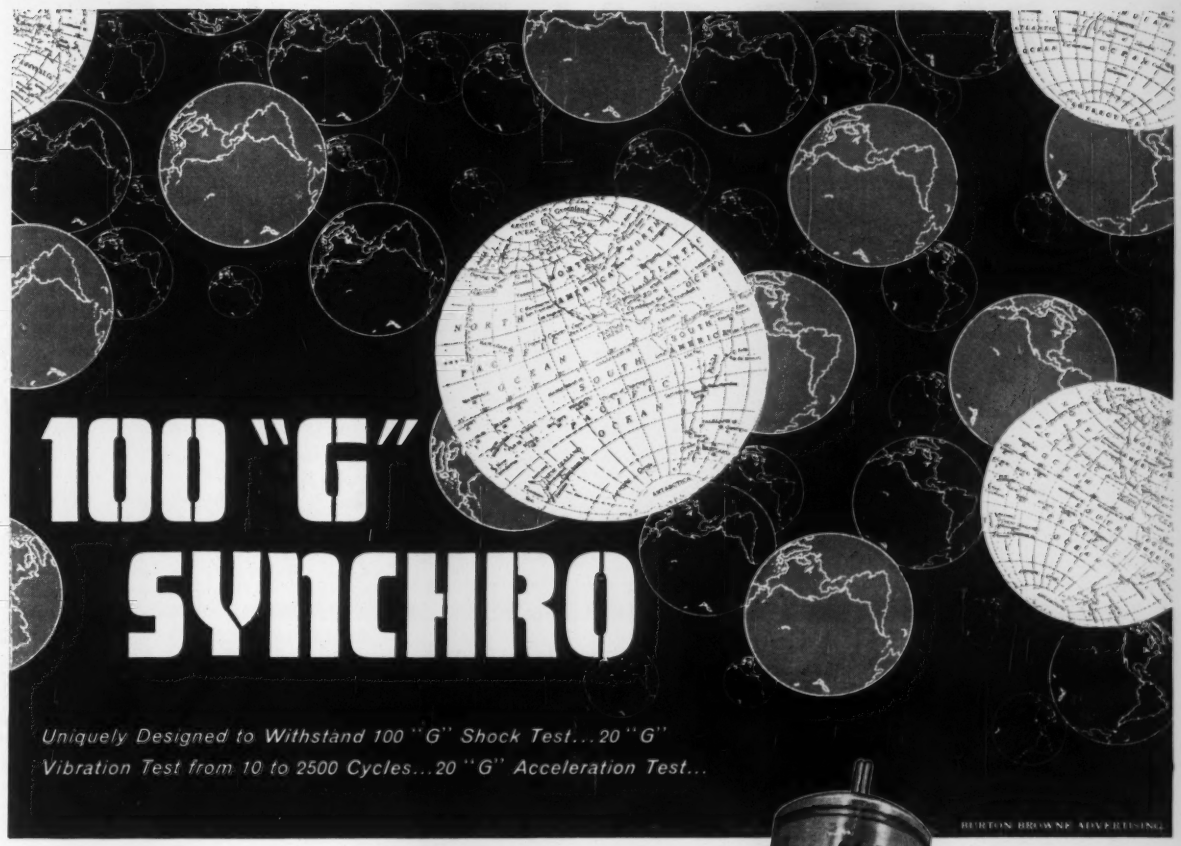
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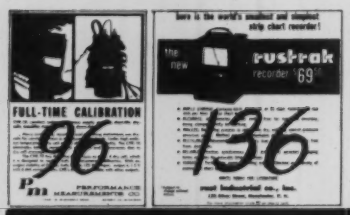

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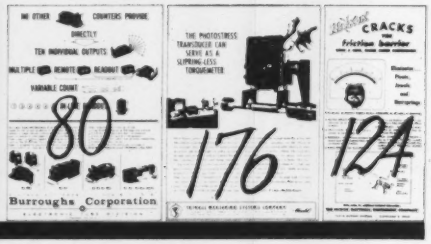

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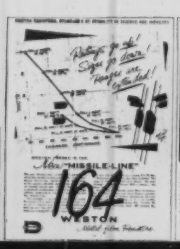

60,000 SALES LEADS PER AVERAGE ISSUE

IAN is the country's top product promoter. Only 36 issues produced the staggering total of 1,911,723 sales leads forwarded to manufacturers. The heavy figures on each ad, shown at the left, indicate the number of sales leads forwarded to manufacturers.

MILITARY SYSTEMS DESIGN

The bi-monthly, king-size magazine devoted to design and application of instrumentation and control in the military equipment market. Read by over 30,000 qualified verified men in government and military-end-product manufacturing industry.

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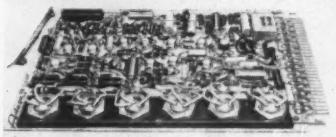
New York, Chicago, Cleveland, Boston, Kansas City, Dallas, Los Angeles, San Francisco, Philadelphia, St. Louis, London, England.

CIRCLE 91 ON READER-SERVICE CARD

TRANSISTORIZED AMPLIFIER

New CV-HZA High Impedance Amplifier using all- transistor circuits handles high voltages and simultaneously provides extremely high input impedance. Functioning as a direct-

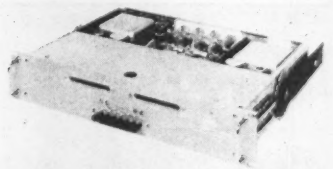


coupled voltage follower its voltage gain is precisely unity. A unique semiconductor chopper-stabilizing technique results in excellent long-term d-c voltage stability. Two models are presently available: Model CV-HZA (±100 v) and Model CV-HZA10 (±10 v).—*Adage Inc., Dept. P,* 292 *Main St., Cambridge* 42, *Mass.*

CIRCLE 192 ON READER-SERVICE CARD

GATE-PULSE GENERATOR

New Gating Unit generates sequential gate pulses and is adaptable to any Arnoux Decommutator, or to any system requiring sequential timing pulses, such as digital computers, a-to-d converters, d-to-a converters, etc. Operation is continuous, even with

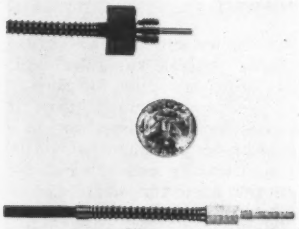


one or several information gates removed. Active readout capability is from 1 to 88 channels, operating on all standard IRIG sampling rates of 30, 45, 60, or 90 channels at from 75 to 900 pps.—*Arnoux Corp.,* 11924 *West Washington Blvd., Los Angeles* 66, *Calif.*

CIRCLE 193 ON READER-SERVICE CARD

TEMPERATURE TRANSDUCER

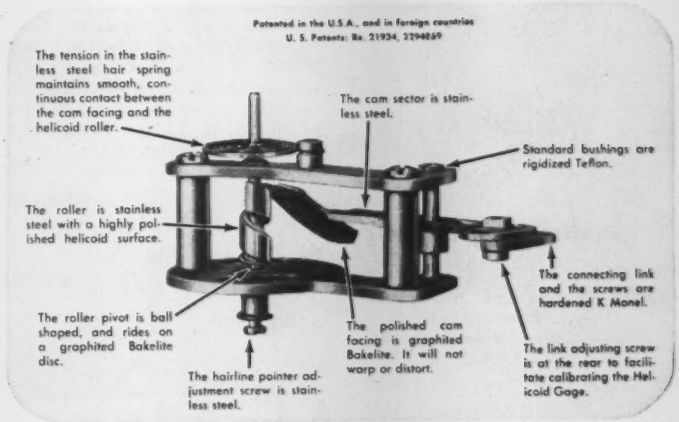
New Tungsten Resistance Thermometer, possessing the high accuracy and wide-temperature-range characteristics (−450°F to + 2000°F) of



the company's standard laboratory probes, features body rotation independent of leads for ease of installation, and is extremely rugged to withstand high vibration and shock. —*Astra Technical Instrument Corp.,* 1132 *Mission St., So. Pasadena, Calif.*

CIRCLE 194 ON READER-SERVICE CARD

ACCO Helicoid Gage U.S.A.


Patented in the U.S.A., and in foreign countries
U. S. Patents: Re. 21934, 2294869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is stainless steel.
Standard bushings are rigidized Teflon.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Exclusive Helicoid movement provides... *Sustained Accuracy... on the toughest jobs*

• Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

NEW! Solid-Front Safety Case Gives Added Protection

The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

WRITE for details **Ask for Catalog DH-65**

HELICOID GAGES

ACCO

Helicoid Gage Division • American Chain & Cable Company, Inc.

929-B Connecticut Ave., Bridgeport 2, Conn.

CIRCLE 92 ON READER-SERVICE CARD

TYPE 310-B Z-ANGLE® METER

Audio & Ultra-Sonic

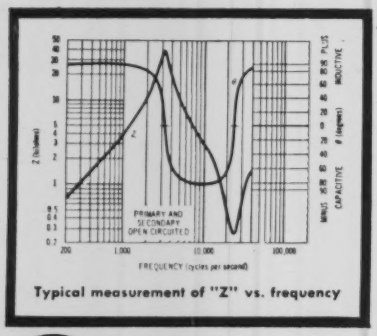
FEATURES:

- **Direct Readings of: Impedance (Ohms), Phase Angle (Degrees), Dissipation Factor (D), Storage Coefficient (Q)**
- **30 cps to 40 kc Frequency Range**
- **Internal 60 and 400 cps Test Signals**
- **Simple to Operate — Only One Balancing Step**
- **Compact and Portable**

The 310-B measures impedances directly in the polar form $Z/\pm\theta$ (i.e., magnitude in ohms and phase angle in degrees). Any RLC combination can be measured from pure resistance, capacitance or inductance to complex impedances. Only one balancing control is used. The condition of sliding balance, frequently encountered when measuring low Q reactances with conventional bridge circuits, cannot exist with the Type 310-B.

Measurements can be made of impedances from 0.5 to 100,000 ohms, from 30 cps to 40 kc. Up to 20 kc, impedance magnitude accuracy $\pm 1\%$ and $\pm 2°$ for angle. From 20 to 40 kc, accuracy decreases somewhat.

Uses include measurements of amplifiers, electro-acoustic transducers, transmission lines, filters, indicating meters and transformers. Fig. 1 shows some typical measurements. Rapid production testing and sorting of electrical components without individual balancing is another application.



Typical measurement of "Z" vs. frequency

ACTON LABORATORIES, INC.

A Subsidiary of Technology Instrument Corp.

531 MAIN ST., ACTON, MASS.

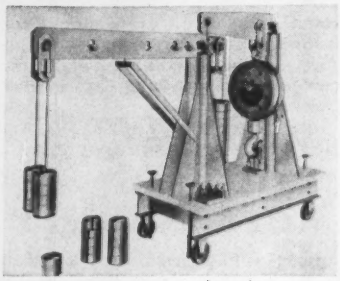
Sales Engineering Office

1225 W. Olympic Blvd., Los Angeles, Calif.

CIRCLE 93 ON READER-SERVICE CARD

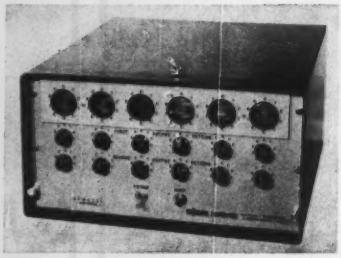
CALIBRATING MACHINE

New Calibrating Machine with knife-blade leverage originally designed for setting the gradations of dynamometers and other Dillon precision instruments to exacting specifications, gives indications that are 99.8% accurate, whether weighing 20,000 lb or a few oz. By varying the relationships of two levers and by resetting the pivot points, load ratios of 10, 20, 40, 75 and 100:1 are possible.— *W. C. Dillon & Co., Inc.*, 14620 *Keswick St., Van Nuys, Calif.*



CIRCLE 195 ON READER-SERVICE CARD

PROCESS CONTROLLER

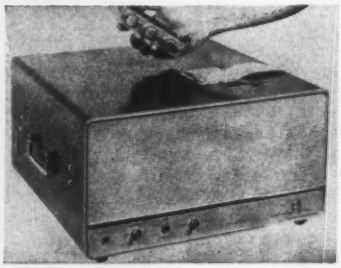


CIRCLE 196 ON READER-SERVICE CARD

New series of transistorized Add-Subtract Digital Process Controllers for bi-directional applications such as automatic-machine-tool positioning, cutting-to-length, coilwinding, etc. operates with company's Add-Subtract Rotopulsers or other bi-directional inputs. Direct-reading numerical display consists of either illuminated Nixies or glow counter decades. Input sensitivity is 1 volt rms at ½ ma.—*Dynapar Corp.*, 5150 *Church St., Skokie, Ill.*

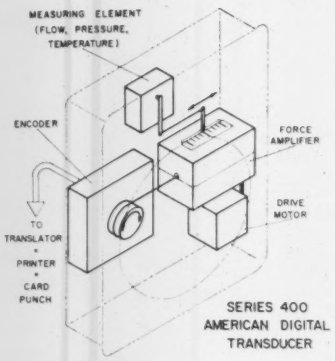
SOLID-STATE PRINTER

New Digital Printer, Model 400C-T, features solid-state electronics and is compatible with all makes of solid-state counting equipment having a 4-line, 1-2-2-4 binary-coded decimal output. It uses transistorized plug-in drivers for each digit which can be changed around to match a variety of outputs from transistorized equipment. Other features include 4 lines/sec printout, no stepping switches, parallel entry, and standard 6-digit printout.—*Computer-Measurements Co., 5528 Vineland Ave., North Hollywood, Calif.*



CIRCLE 197 ON READER-SERVICE CARD

DIGITAL TRANSDUCER

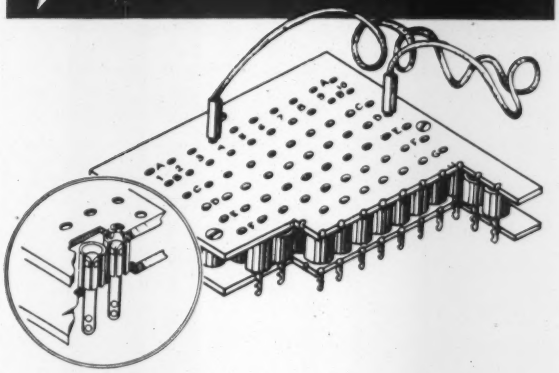


New Series 400 Digital Transducer measures process variables and provides digital encoding for flow, liquid level, pressure or temperature. It employs the completely-mechanical Force Amplifier to position the shaft of a precision an/dig converter and eliminates the need for electronic servos, vacuum tubes, magnetic amplifiers or electronic components. Accuracy is $\pm 1.0\%$ of span. Reproducibility is better than $\pm$ 0.5% of span.—*American Meter Co., Mechanical Components Dept., P. O. Box 309, Garland, Texas.*

CIRCLE 198 ON READER-SERVICE CARD

Vector PATCH BOARDS

FOR RELIABLE CONNECTIONS WHERE SMALL SIZE AND ECONOMY COUNT



Vector Patch-Boards provide simple, economical units for multiple-connection, single conductor patching. Useful for low cost computers, test boards and a multitude of connecting applications. Receptacles are 0.265" on centers and take .087-.091 diameter plugs. Patch cords also available. Standard boards available or readily made to size required.

Write for information:

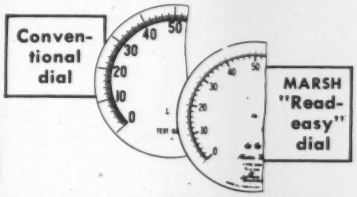
VECTOR ELECTRONIC COMPANY
1100 FLOWER STREET • GLENDALE 1, CALIFORNIA
CHAPMAN 5-1076
CIRCLE 94 ON READER-SERVICE CARD

New MARSH "Master-Test" SERIES

Twin-tip pointer enables observer to read "dead-on" by lining up twin tips like gun sight.

Unprecedented accuracy and dependability in test gauges developed to meet today's exacting requirements. Each gauge individually *dead-weight tested!* Guaranteed accurate within ¼ of 1% plus or minus of maximum dial reading over entire range.

Mirror dial also insures accurate "dead-on" reading.



"Non-parallax" dial has Plexiglas insert that assures accurate reading even when read at angle.

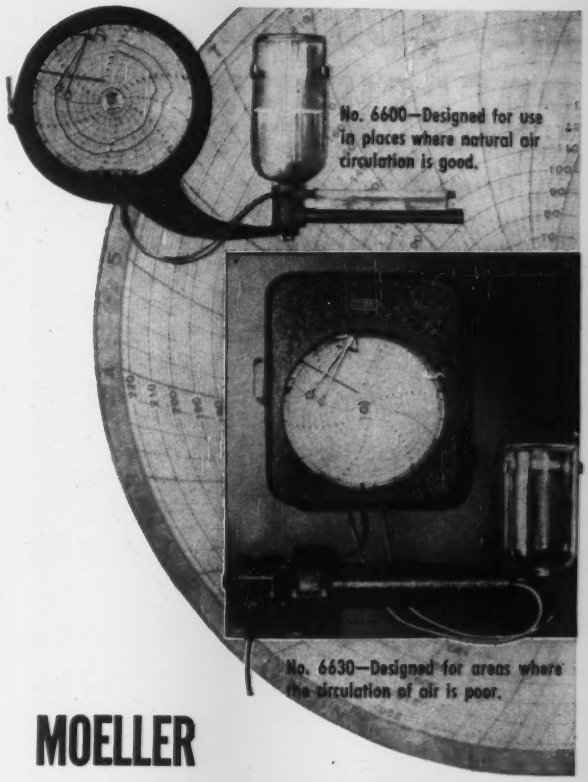
New "Read-easy" dial (patent pending), as illustrated above, assures reading accuracy in keeping with indicating accuracy. Also note three advanced means of reading available in all "Master-test" gauges: twin-tip pointer, mirror dial, and "non-parallax" dial as shown opposite.

Sizes 4½", 6", 8". All standard pressure ranges 0-15 psi to 0-30,000 psi, vacuum and compound.

Ask for new 20 page bulletin covering all details

MARSH INSTRUMENT CO., Dept. 42, Skokie, Ill.
Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co., (Canada) Ltd.
8407 103rd St., Edmonton, Alberta, Canada
Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

CIRCLE 95 ON READER-SERVICE CARD


No. 6600—Designed for use in places where natural air circulation is good.
No. 6630—Designed for areas where the circulation of air is poor.

MOELLER RECORDING PSYCHROMETERS...

With and Without Motor Driven Fan

Record Wet and Dry Bulb Temperatures for Determining Relative Humidity

More than 90 years of experience in design and production are built into the manufacture of these fine precision instruments. Unfailing standards of Moeller craftsmanship provide accurate relative humidity determinations and the invaluable advantage of a reliable permanent record. The choice of units available depends upon air circulatory conditions, AC or DC voltage supplies, and close or remote readings.

Mail the coupon today for complete details!

MOELLER INSTRUMENT COMPANY SINCE 1867
132nd ST. and 89th AVE. • RICHMOND HILL 18, N. Y.
Representatives in Principal Cities

Gentlemen: Without obligation, please send me Catalog No. 150 on Moeller Psychrometers.

NAME .....

FIRM .....

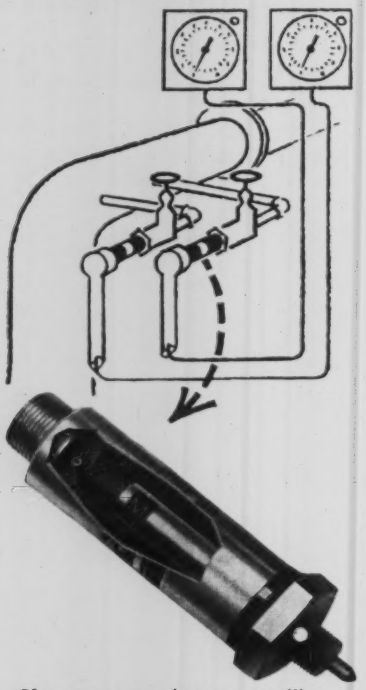
ADDRESS .....

CITY..... ZONE..... STATE.....

CIRCLE 96 ON READER-SERVICE CARD

MEASURING PRESSURE?

For greater accuracy use precision-calibrated SR-4® Pressure Cells



If you are measuring or controlling fluid pressure, you should know these facts about accurate, rugged SR-4® Pressure Cells. Standard accuracy: ±¼% (higher accuracies available for calibration). Calibration does not change with time. Contact fluid directly; require no external piping. Contain no moving parts. Output signal suitable for remote indication, recording or control. Widest pressure range coverage of any commercially-available transducers: 0 PSIA to 100,000 PSIG. Low line, low differential and high frequency models available. Special configurations can be provided.

Write for more information—address Dept. /-I, and ask for Bulletin 4365

FIRST in force measurement

SR-4 BLH BALDWIN LIMA-HAMILTON

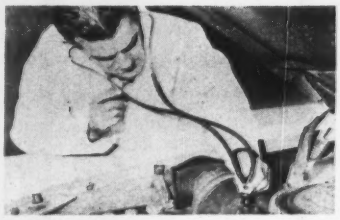
BALDWIN·LIMA·HAMILTON

Electronics & Instrumentation Division
Waltham, Mass.
SR-4® Strain Gages • Transducers • Testing Machines

CIRCLE 97 ON READER-SERVICE CARD

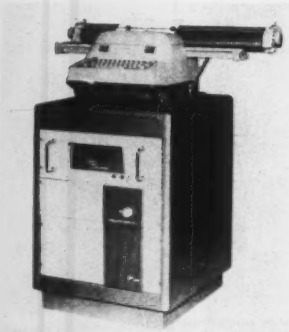
LOW-COST STETHOSCOPE

New low-cost Stethoscope makes unhearable sounds plainly audible. Hot-rodders and others who tinker with machines can diagnose loose joints, poor bearings and valves, strains, or leakage of gas, air or fluid. Householders use it for detecting flaws in piping systems, etc.—*Edmund Scientific Co., Barrington, N. J.*



CIRCLE 199 ON READER-SERVICE CARD

INFORMATION SYSTEM

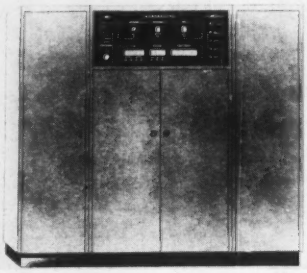


New Pipeline Information System for accurately measuring, transmitting, indicating and recording flow, pressure, temperature, and other pipeline variables in digital form, relays data by standard communication or telemetering equipment to a central control station where it is converted into digital form and recorded by automatic typewriter. Features a single F & P transistorized analog-to-digital converter (ADC). Pipeline variables can be indicated directly in psi, °F, or C, rpm, barrels/min, or other units. —*Fischer & Porter Co., 241 Jacksonville Rd., Hatboro, Penna.*

CIRCLE 200 ON READER-SERVICE CARD

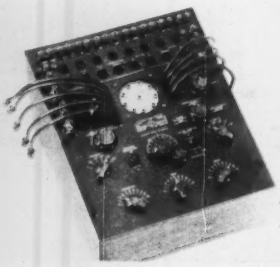
DATA PROCESSING SYSTEM

New Series 2000 solid-state Data Processing System utilizes four basic modular chassis, plug-in housings, and a unique pin-board arrangement for function programming. An electronic scanner continuously monitors 475 variables such as temperatures, flows, and pressures, recording them on demand or at specific intervals. It also monitors for off-normal conditions, sounding alarms when pre-set high or low safety units are exceeded.—*Hagan Chemicals & Controls, Inc., Controls Div., Hagan Blvd., Pittsburgh 30, Pa.*



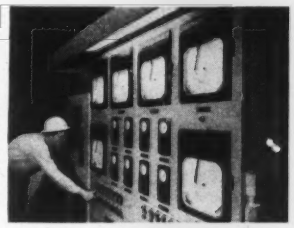
CIRCLE 201 ON READER-SERVICE CARD

TUBE-TRANSISTOR BRIDGE



New direct-reading, dual-purpose V-T Bridge, Type 1661-A, has an amplification-factor (μ) range of 0.001 to 10,000, suitable to measure low-frequency dynamic coefficients of tubes and transistors. Frequency range is 270-400 cps or 1000 cps. The dynamic internal plate-resistance range of the bridge is 50 ohms to 20 megohms; transconductance, 0.02 to 50,000 micromhos. Maximum allowable plate current is 400 ma; maximum plate voltage, 1500.—*General Radio Co., West Concord, Mass.*

CIRCLE 202 ON READER-SERVICE CARD



These Bristol Instruments at Lithium Corporation of America, Bessemer City, N. C., are part of an extensive installation that keeps tabs on such variables as temperature, pressure, absolute pressure, flow, liquid level, and pH.

Almost every industry can benefit from BRISTOL INSTRUMENTATION

Here's an outstanding example of the way Bristol is helping thousands of industrial processes today:

In Lithium Corporation of America's plant for extraction of vital lithium compounds, located in Bessemer City, North Carolina, near this nation's largest ore deposits, precision Bristol instruments monitor and control practically every step of the extraction process.

From the early planning stages, Bristol instrument engineers worked closely with Lithium Corporation engineers in designing the instrument system for this modern plant. Temperature, pressure, absolute pressure or vacuum, flow, liquid level, and pH had to be recorded or controlled at a multitude of points in the complex extraction process. The Bristol instruments used included electronic Dynamaster* potentiometers and pyrometers, pneumatic and time program controllers. In operation for nearly four years now, the Bristol instruments have been doing a precise job of recording and controlling despite vibration and a corrosive, dusty environment.

This is just one example of the way Bristol can work with you in selecting the *right* instruments for your process. Bristol makes the most complete line on the market of full-size and miniature instruments for measurement, recording, automatic control and telemetering of almost every industrial variable. And Bristol Application Engineers are always ready to advise and assist you in applying them to your process. Write: The Bristol Company, 113 Bristol Road, Waterbury 20, Conn.

*T.M. Reg. U. S. Pat. Off. 8.48

BRISTOL TRAIL-BLAZERS IN PROCESS AUTOMATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

CIRCLE 98 ON READER-SERVICE CARD

BARNSTEAD

BANTAM DEMINERALIZER

DOES 5 WATER PURIFICATION JOBS EMPLOYS 5 INTERCHANGEABLE CARTRIDGES

BANTAM

PRESSURE BANTAM

STANDARD CARTRIDGE Produces ion free water at minimum cost . . . removes 1500 grains as NaCl (1300 as $CaCO_3$).

MIXED RESIN CARTRIDGE For operations demanding better than 1,000,000 ohms resistance and neutral pH. Cartridge capacity is 1230 grains as NaCl (1050 at $CaCO_3$). Approximately ⅔ of cartridge capacity is million ohm water or better.

ORGANIC REMOVAL CARTRIDGE Removes organics, organic liquids and gases that would pass through a demineralizer. Effective in removing chlorine. Ideal for pre-treating demineralizer feedwater, for self-purifying high purity rinse systems and other processes where organics or odors in the water are objectionable.

OXYGEN REMOVAL CARTRIDGE Developed for cooling water loops where it is important to maintain low oxygen content to prevent corrosion. Cartridge removes one part per million of dissolved oxygen from 2500 gallons of water, or 6.8 liters (9.7 grains) of oxygen at standard temperature and pressure.

CATION CARTRIDGE Provides (1) precious metals recovery, (2) radio-active isotope recovery, at low cost, (3) also useful for removing volatile amines where heating plant steam condensate is being used as the feedwater for a Still, and (4) where close control over the pH of water is necessary, the cation cartridge in its ammonia or lithium form is effective.

Write for Literature

TRADE MARK REG. U.S. PAT. OFF.

Barnstead

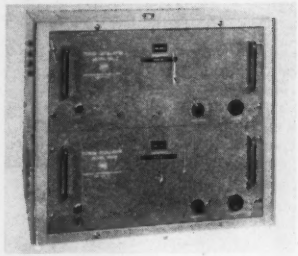
STILL AND STERILIZER CO.

19 LANESVILLE TERRACE BOSTON 31, MASS.

CIRCLE 99 ON READER-SERVICE CARD

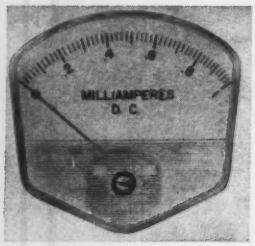
POWER OSCILLATOR

New Model 150-2 Power Oscillator, using silicon diodes, supplies 320 va of power at a fixed frequency of 400 cps ±0.25%. Output voltage is continuously variable from 0 to 120 v for each phase. Features include less than 1% distortion and better than 1% regulation from on load to full load.—*Industrial Test Equipment Co., 55 East 11th St., New York 3, N. Y.*



CIRCLE 203 ON READER-SERVICE CARD

ELECTRICAL INDICATORS

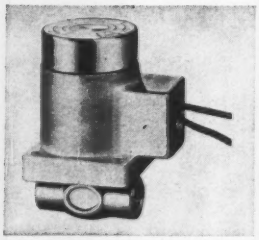


New series of Panel Meters, featuring novel shape and clear plastic construction, have a maximum width of 3½" and are fully interchangeable with all comparable 3½" dia round meters. Available in d-c ranges (Model 1035) from 20 μa to 3000 a, and 10 mv to 750 v; also in matching a-c meters (Model 1036) from 6 ma to 600 a, and 5 v to 600 v. accuracy is 2%.—*Hoyt Electrical Instrument Works, Inc., Burton-Rogers Co., 42 Carleton St., Cambridge 42, Mass.*

CIRCLE 204 ON READER-SERVICE CARD

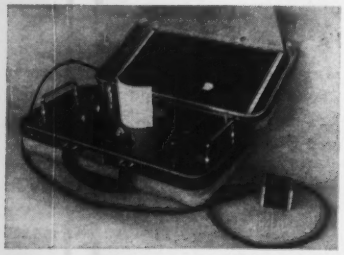
EXPLOSION-PROOF SOLENOID VALVES

New miniature two- and three-way direct-acting Solenoid Valves with explosion-proof and watertight housings, made for n-c, n-o or universal operation, feature a-c shading coils of fine silver; fully-rotatable coil housings; and a broad selection of pipe and tube connections over an orifice range of 1/32" to ⅛" in the Series 90, two-way types; 1/32" to 1/16" in the Series 95, three-way types.—*Hoke, Incorporated, 33 Piermont Rd., Cresskill, N. J.*



CIRCLE 205 ON READER-SERVICE CARD

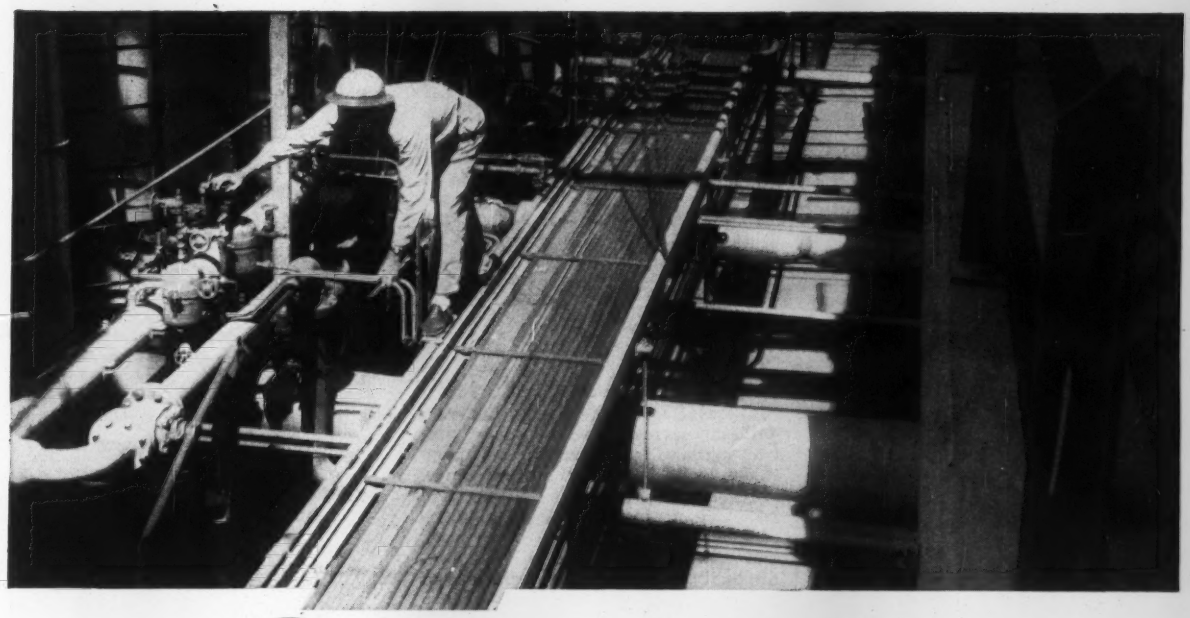
VIBRATION RECORDER



New portable Blastcorder indicates or records the peak acceleration of ground or structural vibrations. One, two, or three pickups may be used. Acceleration is retained by a memory circuit and indicated on the meter; by pressing a button acceleration is printed on the 4" x 6" record placed into a slot.—Bulletin RB-0393 gives details.—*Geotechnical Corp., P. O. Box 28277, Dallas 28, Texas.*

CIRCLE 206 ON READER-SERVICE CARD

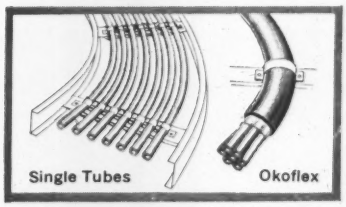
FOR MORE INFORMATION ON PRODUCTS REPORTED OR ADVERTISED, CIRCLE CORRESPONDING NUMBER ON READER-SERVICE CARD ON PAGE 1409. IF THE CARD HAS ALREADY BEEN USED, MARK NUMBER AND DATE OF ISSUE ON POSTAL CARD AND SEND C/O OUR READER SERVICE DEPT.



New 3-WAY approach reduces cost of instrument tubing

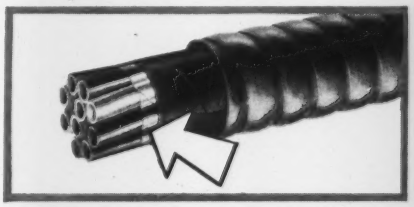
New Okoflex *armored instrument tubing costs less to install than single tubes, yet gives vastly increased resistance to corrosion and mechanical abuse. In addition, **Okoflex costs no more than ordinary multiple instrument tubing.**

Here is the Okoflex three-way approach to reducing your instrument tubing costs:



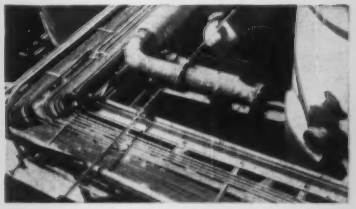
1. Lower installation cost

An Okoflex assembly, consisting of several tubes, takes about the same time to install as a single tube. Existing structures can be used for support, and standard fittings are used for attachment. Armored Okoflex can be "fished" quickly through inaccessible or hazardous locations without fear of tube damage. In addition, Okoflex can be taken down and used over and over again. It is completely salvageable.



2. More durability

Only Okoflex has a Mylar® tape over its core of tubes. This DuPont polyester film provides *extra* protection against both environmental corrosion and galvanic action between the tubes and a metallic covering. One of several Okoflex coverings—each designed for a specific situation—protects the tubes from both physical damage and corrosion. All tubes are tested at not less than 150 psi prior to cabling, and every foot of an Okoflex corrosion-resistant sheath is electrically tested at 4,000 volts to insure that no perforations are present.



3. Tube flattening eliminated

Okoflex cabled tubes—spiraled like strands of rope—can be bent on a small radius without distortion or flattening. Circular in shape, Okoflex' smooth exterior permits easy water and vapor-tight connections with standard fittings. Stresses are distributed evenly to give excellent resistance to mechanical abuse. And on delivery, you'll find that *every* tube is usable . . . none bent or damaged.

* Okoflex is licensed under U.S. Patent No. 2,578,280

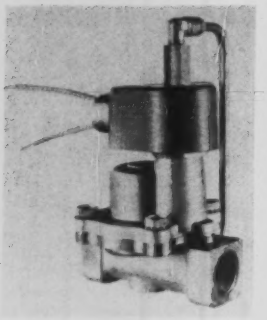
THE OKONITE COMPANY
Subsidiary of Kennecott Copper Corporation
Passaic, New Jersey

OKOFLEX . . . the low cost way to install instrument tubing 8902A

CIRCLE 100 ON READER-SERVICE CARD

DUO-SET TIMERS

New Duo-Set miniature repeat-cycle Dial Timers, Series 306A, are housed in explosion-proof cases which meet NEMA specifications of Class I, Group D, Div. 1 and Class I, Groups E, F and G. Timers control two in-



dependently adjustable load circuits, eliminating the need for two timers. Load ratings are 10 a at 115 vac, 5 a at 230 vac, or ¼ a at 115 vdc. The unit features simple knob-setting of time intervals from ½ sec to 4 hours in a wide selection of dial ranges. Repeat accuracy is one-third of one percent.—*Automatic Timing & Controls, Inc., King of Prussia, Penna.*

CIRCLE 207 ON READER-SERVICE CARD

CONTROL SYSTEM TRANSDUCER

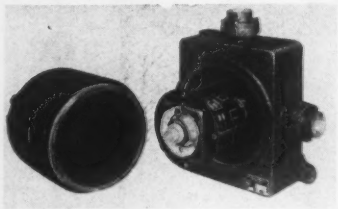
New Hi-Ac-Tran Model 106 Transducer, for installation between new control computers and existing pneumatic equipment, provides high-accuracy conversion of a d-c voltage or

milliamp signal to a pneumatic control signal. Input can range from 0.25-2.5 v to 1-10 v and output ranges are available between 0-1.5 psig and 3-15 psig. Responds to input changes of 0.05 v, has a dead time of 0.02 sec, and a full-range time of 1.25 sec. Linearity and hysteresis deviations of less than 1% are held even at low ranges.—*Associated Control Equipment, Inc., P. O. Box* 136, 853 *Fourth Ave., Coraopolis, Penna.*

CIRCLE 208 ON READER-SERVICE CARD

HI-TEMP SOLENOID VALVES

New 2-way, n-o Solenoid Valves, with internal pilot, handling stream, hot gases, and light liquids up to 350°F., are made in ⅜", ½" and ¾" pipe sizes and have full pipe area orifices. Renewable Teflon discs provide tight seating at pressures to 125 psig.



Listed for a-c service, they can be supplied for d-c service.—Form V5069 (Bulletin 8222A) gives details.—*Automatic Switch Co., Florham Park, N. J.*

CIRCLE 209 ON READER-SERVICE CARD

BINARY/DIGITAL CONVERTER

New Digiverter, a binary-to-digital Converter, features solid-state components. It allows operation of solenoid-actuated typewriter fully automatically without any moving part from the tape-reader as an input device to the completed typewriter function. Can be made compatible for punched-paper tape, magnetic tape, or photo-tape read-out and for the conversion of binary information.—*Commercial Automation Products Co., G.P.O.* 1027, *New York* 1, *N. Y.*

CIRCLE 210 ON READER-SERVICE CARD

MICRO DELTA p CONTROLLER

provides back pressure control in LESS THAN A SECOND!

SERIES 4000

When overshooting the control point is objectionable or intolerable, IEC's Micro Delta p Controller will restore accurate, stable back pressure control—*within a fraction of a second!*

This compact "packaged" system—pressure sensing element and control valve—requires only *one-fourth* the space of a conventional air controller and diaphragm valve. Cost, in many cases, is less than that of a control valve alone.

The Micro Delta p's speed of response—*without hunting*—makes possible the use of multiple control points with minimum transient time. It also features square-wave pressure response and constant pressure throughout full pressure range.

Available now in five types for a wide range of pressure and flow conditions. Write for Bulletin 544 for complete details and prices.

INDUSTRIAL IEC ENGINEERING CORP.

INDUSTRIAL ENGINEERING CORPORATION

529 E. Woodbine, Louisville 8, Kentucky

Designers, engineers, and manufacturers of hydraulic and electronic test equipment, consoles, panels, etc.

CIRCLE 101 ON READER-SERVICE CARD

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THERMAL CONTROLS AND THERMOMETERS

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THE BEST!
A half century of experience is back of every instrument we make. You get assured accuracy and long dependable performance when you specify "Philadelphia." Our specialized staff will be glad to discuss your problem in our field.
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Uniform sharpness over the entire field of view. Erect, unreversed image. Outstanding plasticity; easy on the eyes, even during prolonged observation.

Novel rapid change of magnification from 6x to 160x with wide-angle oculars.

Large working distance from 3-3/4 inches, with diameter of object field up to 32mm. Beyond 80x magnification, the working distance is 1-5/8 inch.

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CIRCLE 103 ON READER-SERVICE CARD

ARE YOU PROPERLY GEARED FOR

MINIATURIZATION?

USE THE PERFECT COMBINATION For **MICRO-DRILLING**

SPHINX

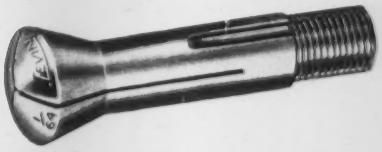
HIGH SPEED STEEL MICRO-DRILLS

Drills from .0016" to .0591" are stocked in increments of .0004"(.01 mm). From.0610" to .1181" in increments of .0020" (.05 mm). Left hand micro-drills for use on Swiss type automatic screw machines. Short flute center drills. Send for Bulletin "Q" listing complete line of drills or Catalog M listing collets as well as full line of instrument lathes and accessories.

Louis Levin & Son, Inc., 3610 S. Broadway, Los Angeles 7, California.

LEVIN ®

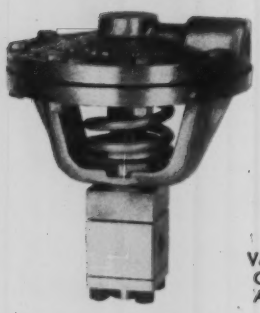
SUPER PRECISION **COLLETS**



Super precision collets for jewelers type lathes. Ideal for holding micro-drills or other parts where concentricity is important. Available from stock in complete range of sizes from .004" (.1 mm) to 5/16" (8.0 mm).

CIRCLE 104 ON READER-SERVICE CARD

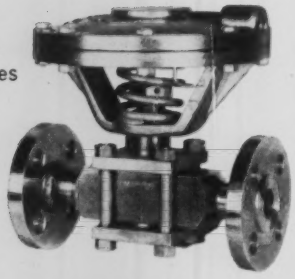
MINIATURE VALVES



501 Series

Valves Shown One-Fourth Actual Size

526 Series



RUGGED

"BANTAM"

THROTTLING CONTROL VALVES

Compact throttling controls of the 501 series have one-piece barstock bodies with screwed ends and are available with linear, equal percentage or quick-opening plug characteristics. This series offers six operators, direct and reverse acting, including two with positioners.

The 526 series includes 6 body styles in globe, angle and 3-way design — with screwed or flanged ends. Four bonnet types cover standard, high or low temperature and packless applications. Six control operators are offered with up to 50 square-inch diaphragms.

	501	526
Pressure Rating	1000 psi (at 450°F)	1000 psi (at 450°F)
Temperature Rating	−70°F to +450°F	−70°F to +450°F (750°F with finned bonnet)
Maximum Cv.	0.63	10.0 (1" connections)
Lift	¼"	7/16"
Seat Area	0.038 sq. in.	up to 0.601 sq. in.
Connections	⅛", ¼", ½" N.P.T. Standard (others available)	¼" to 1" N.P.T. ½" to 1" flanged

Send for the BANTAM Catalog No. B-1 and other technical data on Dahl pneumatic and hydraulic valves.

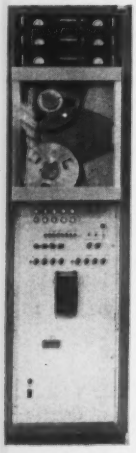
George W. Dahl Company, Inc.
86 Tupelo Street
Bristol, Rhode Island

CIRCLE 105 ON READER-SERVICE CARD

NEW INSTRUMENTS

MAGNETIC TAPE INPUT

New Converter, which makes possible the direct use of digital magnetic tape as input to automatic graph plotters and similar voltage devices,



eliminates the necessity for transferring data from magnetic tape to punched cards. It features solid-state switching circuitry, a point density selector, automatic file and record run-up, parity check, off-scale error count or stop-plot, etc.—*Benson-Lehner Corp.*, 11930 *West Olympic Blvd., Los Angeles* 64, *Calif.*

CIRCLE 211 ON READER-SERVICE CARD

COMPUTER ACCESSORY

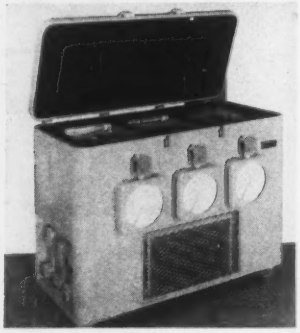
New "piggy back" Duplex Tape Input Unit, shown on top of the standard Model A531 input unit, allows the

Burroughs E101 electronic computer to accept data and instructions from either one of two readers. Control of the unit is provided by the pinboard programming unit.—*Burroughs Corp., ElectroData Div.*, 460 *Sierra Madre Villa, Pasadena, Calif.*

CIRCLE 212 ON READER-SERVICE CARD

ENVIRONMENTAL CHAMBER

New Model SV3-75-5 for multiple environmental testing is equipped with three stainless steel test cells providing a temperature adjustable from (1) 0 to −20°F, (2) − 35 to −45°F, and (3) − 60 to − 75°F. Each com-

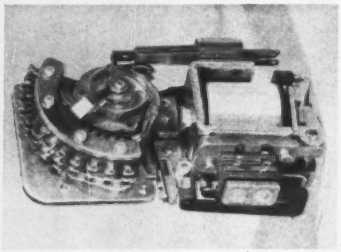


partment is individually controlled. —*Cincinnati Sub Zero Products*, 3932 *Reading Rd., Cincinnati* 29, *Ohio.*

CIRCLE 213 ON READER-SERVICE CARD

STEPPING SWITCH

New 11-point springdriven Stepping Switch, Type 211, with no pawl bear-

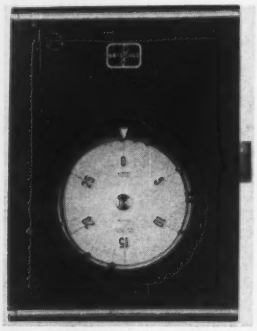


ings, accommodates twelve 11-point levels and up to four 33-point levels. —*C. P. Clare & Co.*, 3101 *Pratt Blvd., Chicago* 45, *Ill.*

CIRCLE 214 ON READER-SERVICE CARD

TIME-CYCLE CONTROLLER

New, improved Time Cycle Controller, Model C1C500, can time-control up to ten different variables for tire presses, dyeing, water condition, and batch processes. Pilots which are

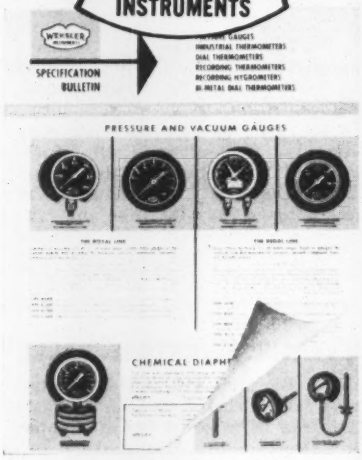


pneumatic, electric, or a combination, can be operated simultaneously or in any sequence and each pilot can perform up to 24 operations. Intervals between operations can be a minimum of four sec, and timing discs range from 0-15 min to 0-360 min.—*Bristol Co., Waterbury* 20, *Conn.*

CIRCLE 215 ON READER-SERVICE CARD

NEW SPECIFICATION BULLETIN

WEKSLER INSTRUMENTS



How to Specify:

- Pressure Gauges
- Industrial Thermometers
- Dial Thermometers
- Recording Thermometers
- Recording Hygrometers
- Bi-Metal Dial Thermometers

Engineers, architects and contractors are finding this Weksler Specification Bulletin a great time saver!

Designed for "at a glance" information and specifications on Weksler instruments most frequently specified for indicating and recording temperature, pressure and humidity, the bulletin illustrates and describes most of the basic instruments needed in air-conditioning, heating, ventilating, plumbing and piping.

WRITE FOR YOUR COPY OF THE WEKSLER SPECIFICATION BULLETIN

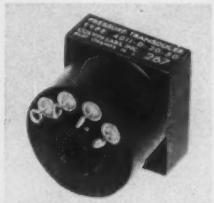
WEKSLER INSTRUMENTS

WEKSLER INSTRUMENTS CORP.
FREEPORT, L. I., NEW YORK
INDICATING AND RECORDING INSTRUMENTS FOR TEMPERATURE PRESSURE AND HUMIDITY

CIRCLE 106 ON READER-SERVICE CARD

PRESSURE TRANSDUCER

New Miniature Series 401 Pressure Transducer accepts vibration of ±35 g at frequencies to 5000 cps, measures 1" x 1", and weighs only 2¼ oz. Avail-

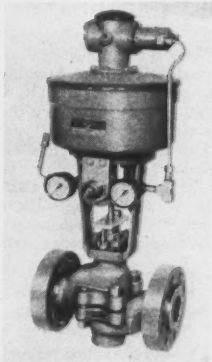


able for absolute, differential, and gage pressures from 0-5 to 0-400 psi, and for differential pressure from ±3 to ±200 psi. Standard nominal potentiometer resistances are 2000, 2500, 5000, 7500, and 10,000 ohms.—*Colvin Laboratories, Inc., 360 Glenwood Ave., East Orange, N. J.*

CIRCLE 216 ON READER-SERVICE CARD

DUCTILE-IRON VALVES

New Series LB and LM Ductile Iron Control Valves afford higher temperature-pressure ratings than cast iron or bronze, and thus greater

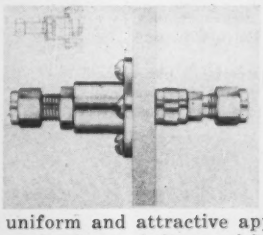


safety. Available in straight-through design in sizes ¾" through 6", with 150-300# ASA raised-face integral flanges, meeting ISA face-to-face dimensions.—*Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.*

CIRCLE 217 ON READER-SERVICE CARD

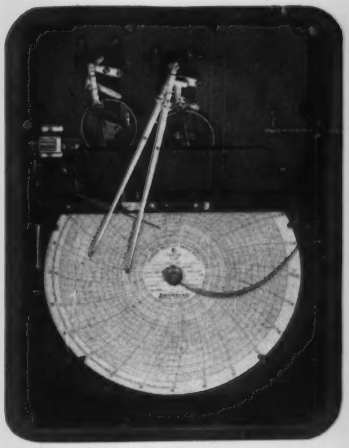
REAR-MOUNTING ADAPTER

New Adapter unit for flush rear-mounting of Swagelok bulkhead fittings on instrument panels permits a



more uniform and attractive appearance on the front of the panel board. Fits ¼" and ⅜" Swagelok Bulkhead Quick Connect.—*Crawford Fitting Co., 884 East 140th St., Cleveland 10, Ohio.*

CIRCLE 218 ON READER-SERVICE CARD



AMERICAN® INTEGRATING ORIFICE METERS

American Integrating Orifice Meters provide more accurate measurement by the continuous multiplication of the square root of the measured differential by the square root of the absolute line pressure.

Single, double and duplex-integrating models available in a wide range of manometer types and working pressures. Dust-proof, die-cast aluminum cases... Gasclok and electric instrument chart drives. Also supplied with American Telecounter for remote readings.

Ask for Bulletin 401 for complete details.

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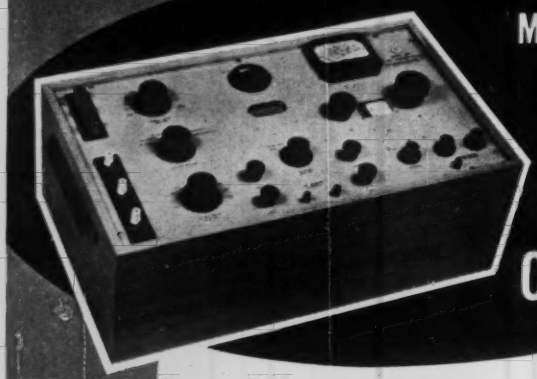
CIRCLE 107 ON READER-SERVICE CARD

from
Instrument Calibration
HEADQUARTERS



Measures Precise AC-DC Voltage & Current

Model 1605
$2450.

A Self-Contained Laboratory Standard Facility

The Model 1605 AC-DC Calibration/Transfer Standard is a multi-function instrument capable of measuring AC and DC voltage and current up to 1500 volts and 15 amperes. It includes a precision four-digit readout potentiometer, laboratory standard cell, precision voltage multipliers, precision shunts hermetically sealed in oil, light beam galvanometer, AC monitoring meter, thermal converter and all necessary batteries and controls. DC measurements utilize the potentiometer or the potentiometer in conjunction with the voltage multipliers or shunts. For AC measurements the potentiometer and/or multiplier-shunt arrangement is used with the compensated AC-DC transfer element.

LIMIT OF ERROR

DC: 0.05% with correction factors; 0.1% direct reading.

AC: 0.065% with correction factors; 0.13% direct reading. (AC accuracies are to 50 kc on most ranges.)

For Owners of the RFL Model 829 AC-DC Instrument Calibration Standard

The Model 1605 may be used in conjunction with the Model 829 to calibrate instruments having greater accuracy requirements than that supplied by the Model 829 alone. The Model 1605 may also be used to calibrate the Model 829. The 829/1605 combination provides a calibration system which will handle your requirements, for current and voltage measurements to an accuracy of better than 0.1%, from DC to 400 cps.

Performance is rigidly guaranteed. Price is net, f.o.b. Boonton, N.J. and subject to change without notice.

SEND FOR TECH. DATA

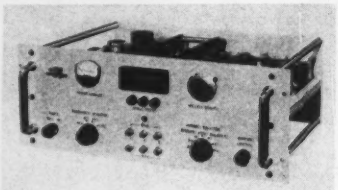
For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

Radio Frequency LABORATORIES, INC.
Boonton, New Jersey, U.S.A.

CIRCLE 108 ON READER-SERVICE CARD

DIGITAL INDICATOR

New servo null-balance Digital Indicator, Type 6R, features high-accuracy multi-channel readout for measurement of flow, pressure, speed, or frequency with pulse producing

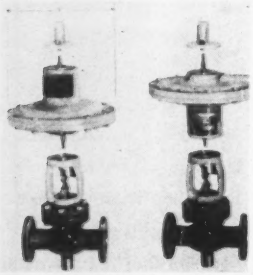


transducers. Accuracy is ±0.25% Linearity is ±0.25% at any point over a 10:1 range. With four-digit readout resolution is up to one part in 9,000. Frequency conversion is completely electronic. A built-in, tuning-fork-controlled frequency standard supplies calibration frequencies with check points at 60, 120, 600, and 1200 cps.—*Cox Instruments Div., George L. Nankervis Co., 15300 Fullerton Ave., Detroit 27, Mich.*

CIRCLE 219 ON READER-SERVICE CARD

REVERSIBLE CONTROL VALVE

New Bantam 540 Series Control Valve has a cast-aluminum actuator which can be inverted for air-to-open



or air-to-close operation. Has Teflon packing and gaskets. C_v range is from 0.002 to 13.2.—*George W. Dahl Co., Inc., 86 Tupelo St., Bristol, R. I.*

CIRCLE 220 ON READER-SERVICE CARD

CURRENT DRIVERS

Two new Current Drivers provide a source of current pulses for testing computer components requiring significant drive currents: Negative Cur-

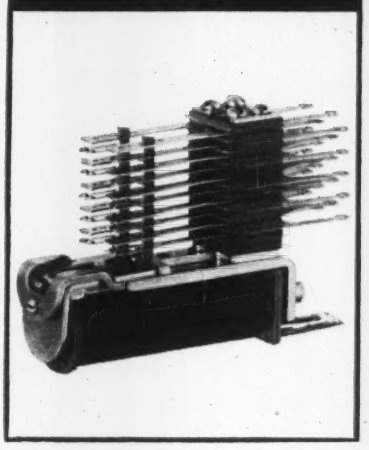
rent Driver Model 50 and Positive Current Driver Model 60 can be used independently or they can be used in conjunction to provide both polarities of pulses. Special features include: maximum one-amp current pulses, 0.1 μsec rise time, regulated filaments and d-c, and three quick-select current levels.—*Digital Equipment Corp., Maynard, Mass.*

CIRCLE 221 ON READER-SERVICE CARD

Stromberg-Carlson

"TELEPHONE QUALITY"

Relays



. . . featuring new high-voltage types for test equipment or other high-voltage applications.

THE insulation in the new relays withstands 1500 volts A.C.—3 times normal. These high voltage models are available in Types A, B and E. They are the latest additions to the Stromberg-Carlson line of twin contact relays—all available for immediate delivery.

The following regular types are representative of our complete line:

Type A: *general-purpose relay with up to 20 Form "A" spring combinations. This relay is excellent for switching operations.*

Type B: *a gang-type relay with up to 60 Form "A" spring combinations.*

Type BB: *relay accommodates up to 100 Form "A" springs.*

Type C: *two relays on the same frame. A "must" where space is at a premium.*

Type E: *has the same characteristics as the Type A relay, plus universal mounting arrangement. Interchangeable with many other makes.*

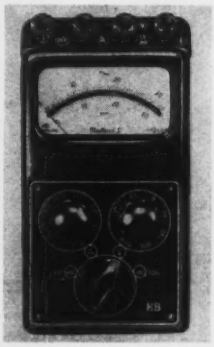
Complete details and specifications are contained in our new relay catalog, available on request. Write Stromberg-Carlson Telecommunication Industrial Sales.

STROMBERG-CARLSON
A DIVISION OF **GENERAL DYNAMICS**
113 CARLSON RD. • ROCHESTER 3, N.Y.

CIRCLE 109 ON READER-SERVICE CARD

MULTIRANGE VOLTAMMETER

New Universal Multirange Voltammeter, H & B MULTAVI 5, imported from West Germany, has 32 ranges for dc and ac. Features mov-

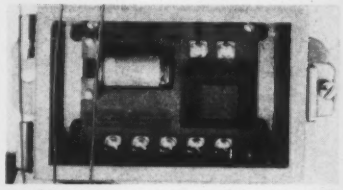


ing-coil core magnet movement and taut suspension, and a 2¾"-long, anti-parallax mirror scale. Accuracy is 1% for dc and 1½% for sine-wave ac.—Two page bulletin gives details.—*Epic, Inc.*, 154 *Nassau St., New York* 38, *N. Y.*

CIRCLE 222 ON READER-SERVICE CARD

LINE TEMPERATURE DETECTOR

New Line Temperature Detector is a multi-point monitor covering an infinite number of points instead of only several pre-determined points. Based

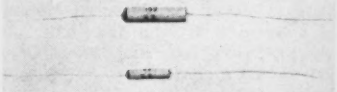


on the temperature-resistance relationship of selected eutectic salt mixtures which are packed into an Inconel tube surrounding a nickel-wire center conductor, a short circuit is caused between the center conductor and outer tube when temperature reaches the set point. The tubing may be bent to practically any desired configuration.—*Fenwal Incorporated, Pleasant St., Ashland, Mass.*

CIRCLE 223 ON READER-SERVICE CARD

ELECTROLYTIC CAPACITORS

New Wet Slug Tantalytics Capacitors are tiny tubular units, in four case sizes ranging from 0.115" to 0.225" dia, 0.312" to 0.875" length; and are rated from 2 to 325 μf, 6 to 60

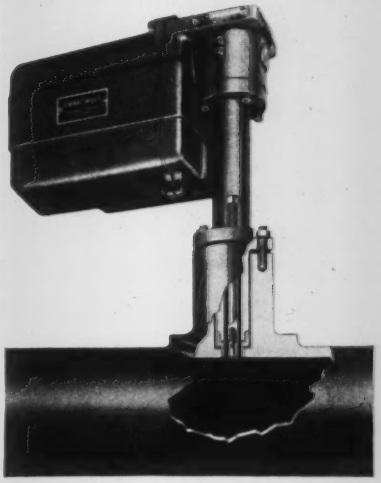


vdc. Having anodes of sintered porous tantalum with a gelled electrolyte, they meet the electrical and environmental characteristics of MIL-C-3965B, except for impedance at lowest temperature ranges.—*General Electric Co., Schnectady* 5, *N. Y.*

CIRCLE 224 ON READER-SERVICE CARD

Great things are happening in AutroniC® Control

TOUGH PROBLEMS ARE NO PROBLEM



FOR THIS FOOLPROOF, FOUL-PROOF PRESSURE TRANSMITTER

Here is a primary sensing element for those tough jobs you'd like to forget. Mounted right on the process pipeline or tank, the Swartwout Flush Diaphragm Pressure Transmitter will effortlessly measure pressure or liquid level of polymers, slurries, asphalts, viscous fluids, molten metals and other difficult media. No stagnant pressure lines, no steam jacketing necessary . . . the stainless steel transmitter diaphragm fits flush with the inside of the vessel.

A friction-free linkage multiplies diaphragm motion and actuates the core of a differential transformer to produce a 0-0.5V AC signal for any Swartwout AutroniC indicator, recorder or controller. Sensitivity is better than 0.005%, reproducibility 0.1%, accuracy 1.0%.

The Flush Diaphragm Pressure Transmitter is just one unit in the constantly-growing AutroniC family of electronic instrumentation . . . a family that includes all necessary components for complete electronic control of any process parameter.

For details on the Flush Diaphragm Pressure Transmitter, request Bulletins A-713 and A-718. The Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio.

SWARTWOUT

. . . world leader in electronic process instrumentation

S-A. 1959

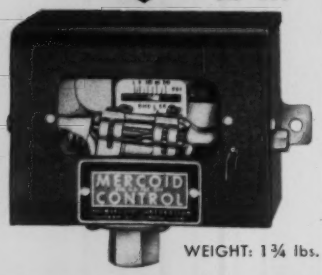
CIRCLE 110 ON READER-SERVICE CARD

NEW

Small, Lightweight

MERCOID PRESSURE CONTROL

AP-153



WEIGHT: 1¾ lbs.

FOR MEDIUMS NOT INJURIOUS TO STEEL OR SILVER SOLDER

CIRCUIT

SP-DT HERMETICALLY SEALED MERCURY SWITCH (4A. 115V., 2A. 230V.)

Provides any of following operations:

1. *Single Pole—Cut-in high (close on rise)*
2. *Single Pole—Cut-in low (open on rise)*
3. *Single Pole—Double Throw*

OPERATING RANGE

ADJUSTABLE OPERATING RANGE	SWITCH DIFFERENTIAL PSIG. With Pointer Set At LOW	HIGH
1 to 20 psig.	0.3	0.5

CONSTRUCTION

ADJUSTMENT: External
PRESSURE ELEMENT: Fairprene diaphragm
PRESSURE CONNECTION: ¼" I.P.S.
MOUNTING: Has two mounting ears (one on each side of control) or control may be pipe mounted by means of the ¼" I.P.S. bottom connection.
INTERNAL WIRING CONNECTIONS: 3 post terminal block.
CASE: NEMA 1—Heavy gauge steel, cadmium plated. Steel cover (with glass front) finished in charcoal-gray.

WRITE FOR BULLETIN 02

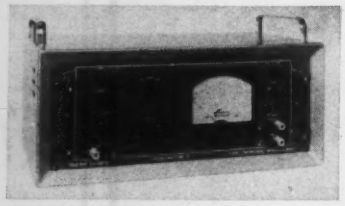
THE MERCOID CORPORATION
4201 Belmont Ave., Chicago 41, Ill.

CIRCLE 111 ON READER-SERVICE CARD

NEW INSTRUMENTS

RANDOM SIGNAL METER

New Random Signal Meter, Model TBM-2, is a true-rms voltmeter with long averaging time, and extended frequency response. Features include:

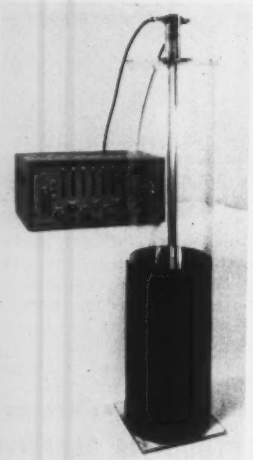


a peak factor of 10 or more; two selectable time constants of 0.5 sec and 16 sec; wide frequency range between 1 cycle and 500 kc; 18 voltage ranges between 0.5 mv and 250 v, extra amplifier and meter outputs, and built-in line regulation.—*Flow Corp., 85 Mystic St., Arlington, Mass.*

CIRCLE 225 ON READER-SERVICE CARD

ULTRASONIC LEVEL MEASUREMENT

New ultrasonic method for continuous measurement of liquid level in liquid nitrogen, many slurries, thick oils, fused salts, molten metals, and many other fluids by the Metasonic

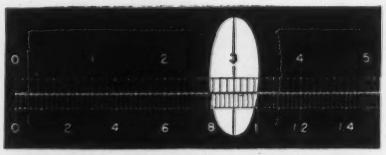


principle, uses solid-metal acoustic wave guides. Temperature range is from cryogenic levels to molten metals. Almost any fluid pressure can be accommodated. Fully transistorized; output is either digital or continuous and adaptable to recording and control, proportioning and blending.—*General Ultrasonics Co., a div. of Acoustica Assoc., Inc., 6 Tobey Rd., Bloomfield, Conn.*

CIRCLE 226 ON READER-SERVICE CARD

AURAL MONITORS

New transistorized units for all tone signalling requirements in re-



METERS THAT TAKE

125,000,000% OVERLOAD!

Because of the **revolutionary** bifilar frictionless (no pivot) movement, plus weightless light-beam pointer, GREIBACH PRECISION METERS withstand 100,000% overload surges. Then, for **extraordinary** overload risk applications, a special built-in Protective Circuit takes up to 125,000,000% overload surges **without impairment.**

FRICTIONLESS BIFILAR SUSPENSION MOVEMENT

Only GREIBACH offers such overload immunity, along with: Sensitivity down to 0.2 microampere full scale. Accuracy better than ¼ of 1%. Energy dissipation as low as 4 x 10^{-10} watt. Permanent reliability. Mechanical ruggedness withstanding up to 500 G's shock.

GREIBACH PRECISION METERS are available in portable, bench and panel models with wide selection of ranges even up to 23 ranges in one meter: e.g., .2/.5/1/2/5/10/20/50/100/200/500μA/1/2/5/10/20/50/100/200/500MA/1/2/5-AMP.

Verify these extraordinary advantages by seeing actual demonstrations arranged upon request.

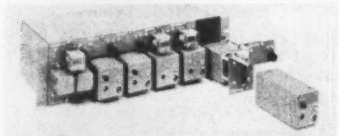
Ask for Literature...

Technical details as well as complete specifications sent on request.

GREIBACH INSTRUMENTS CORPORATION

CIRCLE 112 ON READER-SERVICE CARD

mote supervisory capacities include the MF Module Frame, MS Modular Supply, MT Modular Transmitter, and the MR Modular Receiver. All trans-



mitter and receiver units are entirely self-contained except for the power source.—*Hammarlund Mfg. Co.*, 460 *West 34th St., New York* 1, *N. Y.*

CIRCLE 227 ON READER-SERVICE CARD

SUB-MINIATURE MOTOR

New Sub-Miniature Motor (left in picture), originally used inside the Vanguard II satellite, now available to industry, measuring less than 1"

dia and only 1-⅜" in length, operates on only 0.1 watt of power. Speed is 2,500 rpm. It has a permanent magnet within the rotating coils, and is equipped with ball bearings.—*A. W. Haydon Div. of Consolidated Electronics Industries Corp.*, 100 *East 42nd St., New York* 17, *N. Y.*

CIRCLE 228 ON READER-SERVICE CARD

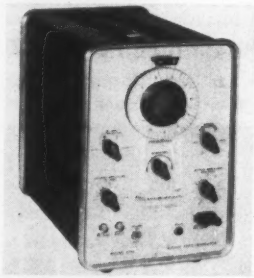
COMPUTER TYPEWRITER

New fully alphanumeric Typewriter for the G-15 digital computer requires no manual encoding of alphabetic data, conversion subroutines or programmed carriage shifts.—*Bendix Computer Div.*, 5630 *Arbor Vitae St., Los Angeles* 45, *Calif.*

CIRCLE 229 ON READER-SERVICE CARD

SQUARE-WAVE GENERATOR

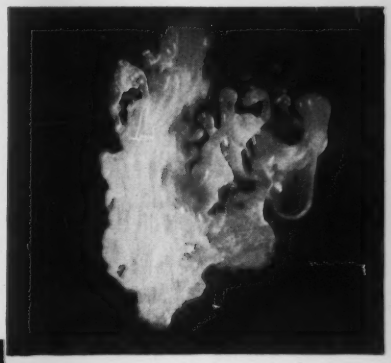
New Square-Wave Generator provides excellent rise time (0.02 μsec) for pulse work and a wide frequency

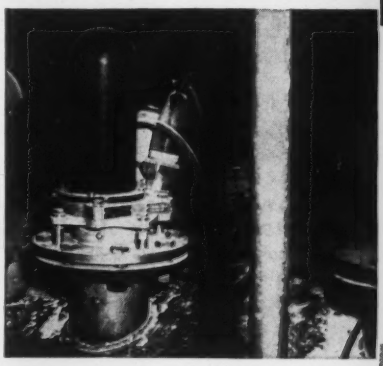


coverage from 1 cps to 1 Mc. Frequency range is covered in 6 decade bands.—*Hickok Electrical Instrument Co.*, 10528 *Dupont Ave., Cleveland* 8, *Ohio.*

CIRCLE 230 ON READER-SERVICE CARD

YES, NOW VISCOSITY



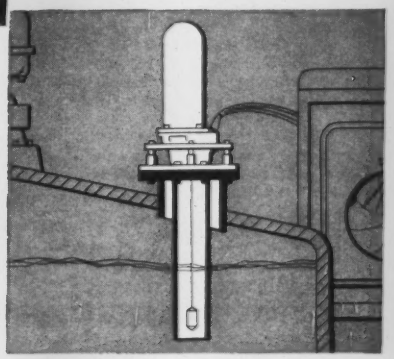


CAN BE CONTINUOUSLY

PROCESS CONTROLLED

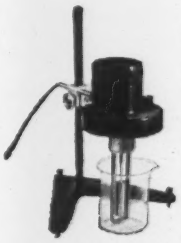
WITH THE

BROOKFIELD VISCOMETRAN



UNDER actual process conditions, the Brookfield Viscometran accurately and continuously measures, records and controls viscosity. Readily mounted and integrated in existing processes, the Viscometran offers significant economic advantages over other methods of indicating degree of reaction, degree of polymerization or determination of process end point.

Viscosity is very likely a variable that is fundamental in your process. For complete information about how the Brookfield Viscometran can provide continuous "in process" measurement of this product dimension for you, write—



THE WORLD'S STANDARD FOR VISCOSITY MEASUREMENT AND CONTROL

Brookfield

ENGINEERING LABORATORIES, INCORPORATED

STOUGHTON 316, MASSACHUSETTS

BROOKFIELD VISCOMETRANS NOW SUCCESSFULLY USED FOR CONTROLLING:

Asphalt • Caramel • Cement slurries • Durezresin-acetone slurries • Gluten slurries • Lignum-based polymers • Molten P_2S_5 • Paper coatings • Polystyrene • Polyurethane resins • Ureaformaldehyde resin

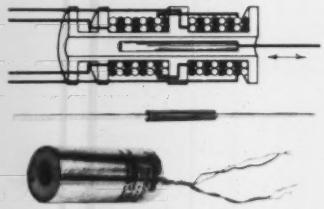
CIRCLE 113 ON READER-SERVICE CARD

± 3 micron sensitivity in this typical differential transformer application. The ATCOTRAN® differential transformer measuring probe continuously senses amount of stock removed from work piece during this grinding operation, stops feed above established grinding dimensions, and simultaneously starts timed dress-up. Automatic cut-off at end of dress-up actuates withdrawal and stops spindle motor. Probe tip may be equipped with diamond point, roller, shoe or other work contact element suitable for position, thickness or tolerance measurement. Displacement measuring range is from 0 to 0.025 inches.

PICKUP → CONTROL RELAY → CONTROLLER

SYSTEM-PROVED STANDARD ATC DIFFERENTIAL TRANSFORMERS

INCREASE SENSITIVITY, SIMPLIFY CIRCUIT DESIGN



WHAT IS A DIFFERENTIAL TRANSFORMER? An electromechanical device which continuously translates displacement or position change into linear AC voltage.

WHAT ARE ITS ADVANTAGES? It is frictionless, has infinite resolution, high signal to noise ratio, low null voltage, unaffected by wide temperature ranges or radiation exposure, linear to 1/10th of 1%, small in size and weight.

WHERE ARE ATC DIFFERENTIAL TRANSFORMER SYSTEMS IN USE? In numerous industrial and military applications where sensitivity, economy, and consistent performance are demanded in a control or indicating system.

HOW CAN I FIND OUT HOW DIFFERENTIAL TRANSFORMERS WILL HELP ME?

Send for ATC's free 32 page "Handbook of Linear Transducers," which gives theory, characteristics, curves, schematics and application data.

HOW CAN I EXPERIMENT WITH DIFFERENTIAL TRANSFORMERS?

ATC's Experimental Kit offers all essentials for experimentation and development: technical data, seven transformers (linear range ± 0.01 to ± 2.5 inches), flexure plate and mounting clamp, and demodulator.

(A)

(B)

(C)

(D)

ATCOTRAN COMPONENTS

(A) Pressure Pick-up measures and controls flow of gas or liquid.
(B) Edge Guide senses edge position of continuous strips.
(C) Amplifier operates from input of any Atcotran sensing device.
(D) Servo Mechanism to position remote indicators with precise accuracy.

atc

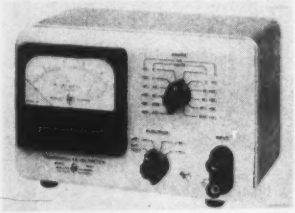
AUTOMATIC TIMING & CONTROLS, INC.
KING OF PRUSSIA, PENNSYLVANIA
A SUBSIDIARY OF SAFETY INDUSTRIES, INC.

CIRCLE 114 ON READER-SERVICE CARD

NEW INSTRUMENTS

PORTABLE A-C VOLTMETER

New general-purpose transistorized A-C Voltmeter, Model 403A, with a frequency range of 1 cps to 1 Mc, measures a-c voltages from 1 mv full scale to 300 v full scale with an ac-

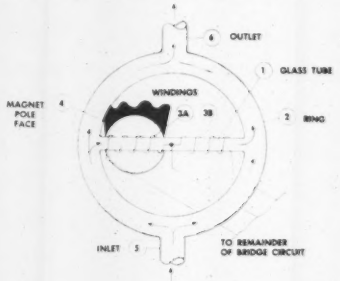


curacy of ±3% from 5 cps to 500 kc; and ±5% from 1 to 5 cps, and from 500 kc to 1 Mc. Instrument has 12 voltage ranges and also reads db from −72 to +52 db. Particularly useful in measuring sub-audio voltages such as those in geophysical and medical instruments and servomechanisms.—*Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.*

CIRCLE 231 ON READER-SERVICE CARD

LOW-RANGE GAS ANALYZER

New Model 632 Low Range Gas Analyzer for 0-1% to 0-3% oxygen is based upon a new concept of the fun-



damental paramagnetic oxygen measuring principle unaffected by fluctuating H_2 concentrations up to 50% of the sample gas content. Accuracy is ±2% of range. Principle is shown in picture.—*Hays Corp., Michigan City, Ind.*

CIRCLE 232 ON READER-SERVICE CARD

ALPHA NUMERIC READOUT

New in-line in-plane Alpha-Numeric Display Model SGS-401 uses

only one input per character. Standard model displays 26 letters and 10 digits.—*I.D.E.A., Inc., 7900 Pendleton Pike, Indianapolis 26, Ind.*

CIRCLE 233 ON READER-SERVICE CARD

If the cost of metal stampings and wire forms figures in your profit picture, let us give you a quotation on your current components. Send us a sample or blueprint . . . and discover how big savings in time and production costs, big gains in precision and uniformity are possible on small components, when Art Wire tackles the job!

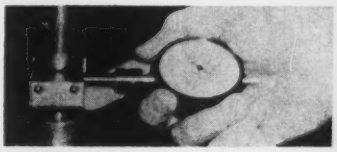
Our engineering staff, our production experience, and our modern high speed equipment are always at your disposal. If you wish to learn more about what a wide and versatile range of shapes and parts we can produce for you—at lower cost than you'd guess—just write for our illustrated folder.

ART WIRE AND STAMPING CO.

35 Boyden Place, Newark, New Jersey
CIRCLE 115 ON READER-SERVICE CARD

PRESSURE GAGE

New type Pressure Gage for measurements up to 2500 psig functions by measuring the deflection of two

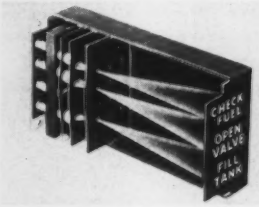


simple beams of tempered spring steel. Accuracy is ±4%. Only ⅝" thick, it is suited for checking electrode pressure on welding equipment, and other difficult measurements.—*Instrument Control Co.*, 1554 *Nicollet Ave., Minneapolis 3, Minn.*

CIRCLE 234 ON READER-SERVICE CARD

READOUT DISPLAY

New, large rear projection-type readout displays word messages by means of a condensing lens. Overall

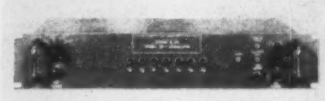


size is 3¼" wide, 5¼" high, and 11½" long.—*Industrial Electronic Engineers, Inc.*, 3973 *Lankershim Blvd., North Hollywood, Calif.*

CIRCLE 235 ON READER-SERVICE CARD

DATA TRANSMISSION SYSTEM

New, completely-transistorized Data Transmission System consisting of a Model SE-1 Encoder and a Model SD-2 Decoder converts a standard



paper-tape-reader output to an error-reducing format for transmission over relatively narrow band communications links, and back to parallel form providing signals for driving a standard punch.—*Kauke and Co.*, 1632 *Euclid St., Santa Monica, Calif.*

CIRCLE 236 ON READER-SERVICE CARD

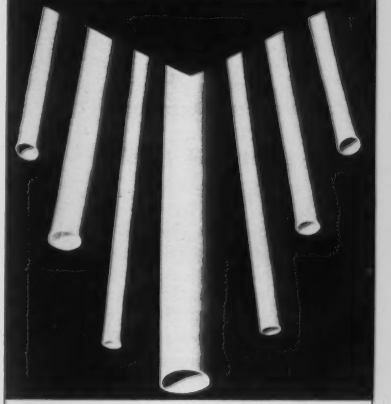
ELECTRICAL INDICATORS

New Precision Meters having a patented bifilar-suspension movement, are available as microammeters, milliammeters, ammeters, millivoltmeters, voltmeters, megohmmeters, multirange meters to 23 ranges, and voltammeters for current and voltage in the same instrument.—*Greibach Instruments Corp.*, 315 *North Ave., New Rochelle, N. Y.*

CIRCLE 237 ON READER-SERVICE CARD

for missile and radar sleevings, cable sleevings, barrier insulation, and similar applications, use large size

Electrical Tubing
MADE FROM
TEFLON*



PF tubing made from Teflon in sizes from ⅜" to 1" for electrical applications is widely used because of:

1. the OUTSTANDING electrical and physical properties of Teflon, including: dielectric breakdown (18,000 volts or greater); lowest dielectric constant (2.0); no change of electrical properties with temperature (−25°C. to +250°C.) or frequency (60 cycles to 100 mc); unaffected by moisture; low coefficient of friction; flexibility; very low permeability.

2. the OUTSTANDING design, engineering and production techniques developed by Pennsylvania Fluorocarbon to assure you of: tubing that is consistently uniform in dimensions; prompt deliveries; the tailoring of Teflon with colors for identification or with modifications for improved texture and mechanical properties; competitive prices.

Write, wire or call for a prompt quotation on your needs.

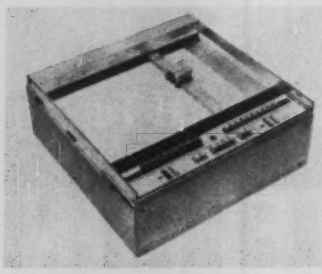
PENNSYLVANIA FLUOROCARBON CO., INC.
1115 N. 38th Street, Phila. 4, Pa.
EVergreen 6-0603 TWX: PH 252
*Du Pont registered trademark

CIRCLE 116 ON READER-SERVICE CARD

NEW INSTRUMENTS

X-Y PLOTTER

New pushbutton-operated X-Y Plotter, Model 210, features immediate scale switching with vernier con-



trol, static accuracy of ±0.2% of full scale, and a dynamic accuracy of ±0.2% of full scale at 10"/sec tracing speed.—*Librascope Incorporated, 808 Western Ave., Glendale 1, Calif.*

CIRCLE 238 ON READER-SERVICE CARD

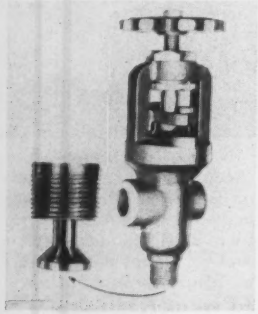
300-MM LENS

New Tele-Xenar 300-mm, f/5.6 Lens, a true telephoto lens providing 6X magnification for Robot automatic 35-mm cameras, is especially suitable for rapid-action photography at ball games, races or other sport events.—*Karl Heitz, Inc., 480 Lexington Ave., New York 17, N. Y.*

CIRCLE 239 ON READER-SERVICE CARD

DRAIN OR SAMPLING VALVE

New Jerguson No. 23 Drain or Sampling Valve is completely self-draining. Recommended for pressures



up to 4000 psig at 100°F., or 1000 psig at 750°F, for ¾" and 1" size, it has ¾" NPT male tank connection and ¾" NPT female drain connection. Other sizes available are 1", 1½" and 2".—*Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.*

CIRCLE 240 ON READER-SERVICE CARD

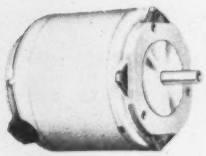
RECORDER PEN

New Recorder Pen of polystyrene is made (1) as a small model for use with Model 137 "Infracord" infrared spectrophotometer; and (2) as a large model, designed for Models 21, 221 and 4000-A spectrophotometers. It is claimed that the pen eliminates leaking, or clogging, and skipping.—*Perkin-Elmer Corp., Norwalk, Conn.*

CIRCLE 241 ON READER-SERVICE CARD

SYNCHRONOUS MOTOR

New Slo-Syn, an enclosed permanent-magnet-type synchronous motor, has accurately controlled speed of 72 rpm at 60 cps without gear reduction. Torque is 150 in-oz. A single-



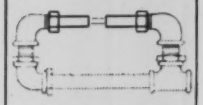
pole, three-position switch can give instant starting, stopping, and reversing control because the motor has three leads only. When used as a stepping (or "inching") motor, d-c impulses are converted into either 200 or 400 precise increments of one revolution of the motor shaft.—*Superior Electric Co., Dept. SS, Bristol, Conn.*

CIRCLE 242 ON READER-SERVICE CARD

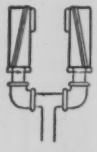
TURNS COUNTING DIAL

New Turns Counting Dial, Verni-Dial Model H5850, made of lightweight

Remote Heads for Small Space



E8-E8P3 Remote heads mounted together on ½" conduit. Also available with fixed focus pin point beam.



E1A-
E1AP

Compact, rugged—easily positioned remote heads. Available with ¼" diameter straight beam—also fixed focus pin point beam.

Reliable Photoelectric Controls

for tension, jam-up, registration, illumination, liquid and material level – sorting, measuring, weighing, inspection–die-protection, smoke detection, packaging, processing.

Heavy Duty Industrial Photoelectric Equipment

Includes normal, high speed, ultra-sensitive and impulse actuated photoelectric controls – also latest tubeless photoelectric controls – with wide selection of light sources.

Catalogs describing above equipment and including diagrams of widely varied applications mailed promptly on request.

Send for your copy or tell us about your requirements.

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CIRCLE 117 ON READER-SERVICE CARD

PhotoStress Gage

Without wiring or instrumentation this new PhotoStress Gage will give direct visual readings of strain. Contrasting color bands in the gage shift in direct proportion to applied strain. When used for transducer applications, the gage is calibrated for readings in terms of load, torque, pressure. It also indicates misalignment. Strain sensitivity will be within 20 or 40 microinches/inch, depending upon the type of gage.

Write for complete details—Dept. I-9.

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Comparative quality tests by one of America's leading users of tubing proved only Precision Tubing rates excellent in all specifications . . . yet Precision Tubing costs no more.

Precision Tubing is unequalled and unsurpassed in quality tests of accuracy, temper, straightness and roundness. You are sure of extra quality in every size tube at regular mill prices. Available in sizes from .010" to 1.125" O.D. in copper, brass, aluminum, up to ⅝" O.D. in nickel and nickel alloys, Ni-Span "C", phosphor bronze and nickel silver. In straight random lengths, coils or preformed shapes to specifications.

Write for catalog and technical data to Dept. 9, Precision Tube Company, Inc., North Wales, Pa.

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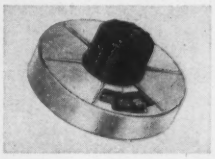
PRECISION TUBE COMPANY

CIRCLE 119 ON READER-SERVICE CARD

plastic, consists of an inner dial, graduated in hundredths of a turn, and an outer dial which accumulates the number of completed turns to 20 turns. Rotation of the inner dial

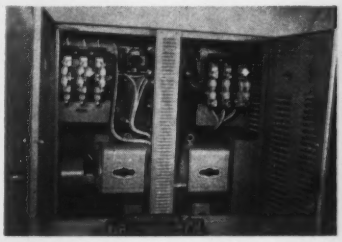


through a Geneva movement indexes the outer dial at the completion of each turn. Fits shafts of potentiometers, capacitors, valves, and other equipment where micrometer readout of their setting is required.—*Howell Instrument Co.*, 3101 *Trinity St., Fort Worth 7, Texas.*

CIRCLE 243 ON READER-SERVICE CARD

FREQUENCY CONVERTER

New packaged Frequency Converting System consists of switchgear for both motor and generator, with the converter mounted on a struc-

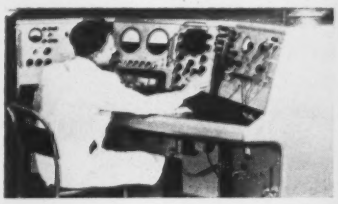


tural steel base as an integral part of the base, all mounted in a cubical. The 60-to-400-cps frequency converter has an output of 30 kw when operated at 3428 rpm. The generator is rated 30 kva, unity power factor, 3 phase, 120 v delta.—4-page Bulletin MG 659 gives details.—*Kato Engineering Co., Mankato, Minn.*

CIRCLE 244 ON READER-SERVICE CARD

SERVOTEST CONSOLE

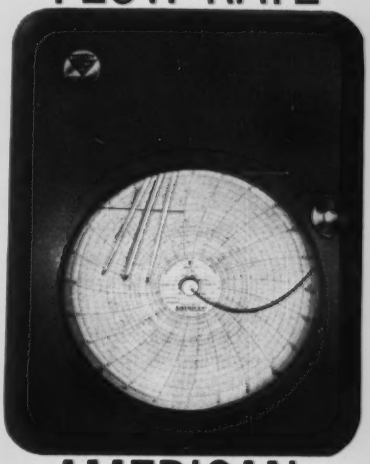
New Console is designed to house Solartron instruments such as the low-frequency decade oscillator, low-frequency resolved components indi-



cator, Solarscope, converters, subsonic power amplifier, or mechanical reference generator. Other instruments in the servotest field can also be accommodated.—*Solartron, Inc., Western Div.*, 10761 *Burbank Blvd., North Hollywood, Calif.*

CIRCLE 245 ON READER-SERVICE CARD

PRECISION MEASUREMENT AT ANY FLOW RATE



AMERICAN-WESTCOTT A-88 ORIFICE METERS

Versatile American® Series A-88 mercury-type orifice meters meet the toughest flow measurement requirements – working pressures to 5,000 psi – interchangeable 10, 20, 50, 100 and 200-inch ranges. Recording meters may be equipped with 0-150° F. standard temperature element. Integrating meters integrate static and differential pressure, providing totalized flow indications. Telemetering equipped meters transmit integrated indications to remote locations.

- Manometer body easily cleaned – does not affect calibration.
- Tamper-proof calibration – simple, positive adjustment of float lever arm length.
- Interchangeable ranges – no manifold piping changes.
- Teflon-packed stuffing box is pressure tight, nearly frictionless, never needs lubrication.
- Teflon-packed pulsation dampener externally adjustable under full line pressure.
- Check valves give positive shut-off for over-range protection.

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CIRCLE 120 ON READER-SERVICE CARD

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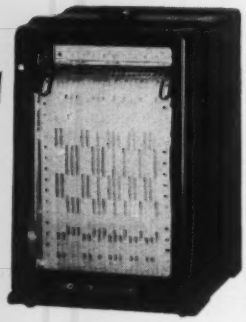
EVENT RECORDER

Give You the Answers



With as many as 20 pens writing on a moving chart, the *E-A Event Recorder* gives you a permanent record of such important facts as:

- **when events occur,**
- **how frequently they occur,**
- **how long they last,**
- **the relationship of a series of events to each other.**

Such data is extremely helpful in establishing and maintaining cycles of automatically controlled operations and processes . . . recording life tests and time of failure . . . positions of valves and levers, etc.

Send for Catalog Section 50 and see how E-A Event Recorders can help you.

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in modern scientific instruments often depends on controlling the direction of light without:

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DIFFUSION

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- beam splitters
- optical filters

Send for our free booklet. We have experience and skill to put at your service in solving your individual light problem.

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CIRCLE 122 ON READER-SERVICE CARD

NEW INSTRUMENTS

OSCILLATOR

New Model GO-20F, a wide-frequency Oscillator covering the band 10 cps

to 5 Mc, features a 50-ohm output impedance, a Wien-bridge-stabilized oscillator, frequency stability of 1% (after warmup), distortion of less than 2%, and continuous control of the output-voltage level. Applications include: testing 50-ohm systems, circuit development, signal generation, alignment, use as basic laboratory tool, etc.—*Gerber Scientific Instrument Co., 89 Spruce St., Hartford 1, Conn.*

CIRCLE 246 ON READER-SERVICE CARD

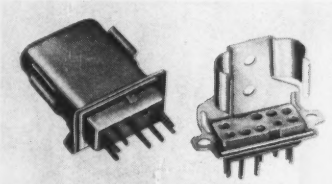
THERMISTORS

New Veco Lox bead-and-probe type Thermistors for low-temperature liquids are made as 0.43"-dia. beads (05A1 and 05A2), and ½"- and 2"-long probes (05A3 and 05A4). Features include: resistance (at −195.8°C)—300,000 ohms ±50%; time constant in liquid nitrogen—less than one sec; dissipation constant at 25°C—1 mw/°C in still air, 5 mw/°C in still water; temperature coefficient (at −195.8°C)—approx. −20%/°C.—*Victory Engineering Corp., 562 Springfield Rd., Union, N. J.*

CIRCLE 247 ON READER-SERVICE CARD

RELAY SOCKET ASSEMBLY

New high-quality Micro-Miniature Relay Socket Assembly, specially designed for use with Micro-Miniature relays conforming to MIL-R-5757, features unit packaging of socket and

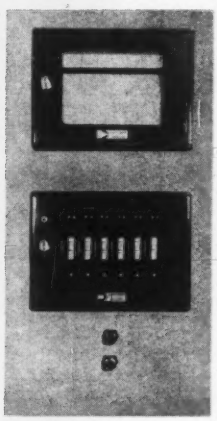


holding clip. Holding clip is available with either beryllium copper alloy 25 (per QQ-C-533), or annealed carbon steel SAE 1065 per MIL-S-17919 (Navy) No. 4. Both clips are cadmium plated per QQ-P-416A, Class 3, Type II, golden iridite.—*Augat Bros., Inc., 33 Perry Ave., Attleboro, Mass.*

CIRCLE 248 ON READER-SERVICE CARD

RECORDER-CONTROLLER

New Recorder-Controller combination, consisting of a multipoint recorder and controller, can control up to six points and record up to 24 points. It features the ability to operate from either one or two separate



thermocouples or other inputs per point. Positive protection against failures of either half of the system is provided when the dual inputs are used. Both "on-off" and proportional electric control are available. Pneumatic control can be supplied by the use of electro-pneumatic converters. —*Daystrom-Weston Industrial Div., Daystrom, Inc., 614 Frelinghuysen Ave., Newark, N. J.*

CIRCLE 249 ON READER-SERVICE CARD

HIGH-SPEED COUNTER

New miniature High-Speed non-reset Counter is an external-pinion type with nylon wheels and ⅛" white

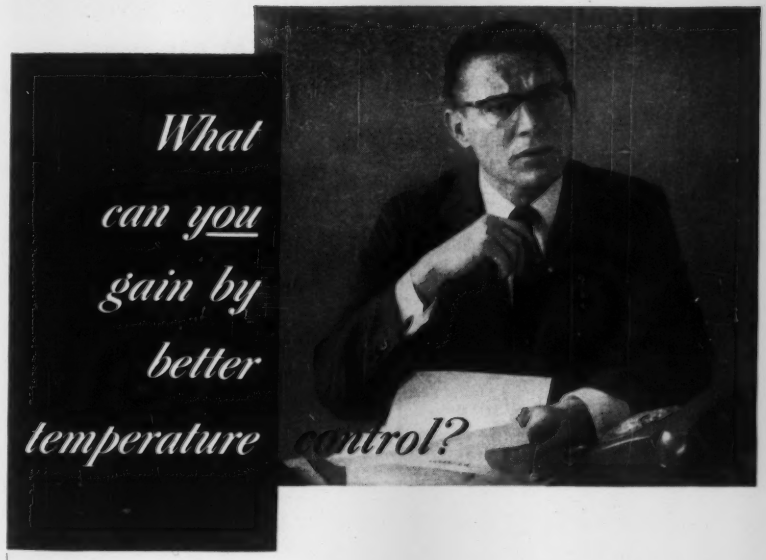
characters on black. Maximum torque is 0.010 in-oz at 25°C, and max. operating speed is 1000 rpm.—*Veeder-Root Inc., Instrument Div., Hartford 2, Conn.*

CIRCLE 250 ON READER-SERVICE CARD

NON-DUMPING RECORDER PEN

New Type B Pen for mobile refrigeration improves the problem of ink-dumping on recorders as it features a built-in ink reservoir and operates on a capillary tube principle.—*Partlow Corp., 527 Campion Rd., New Hartford, N. Y.*

CIRCLE 251 ON READER-SERVICE CARD

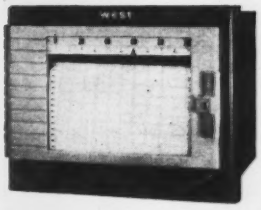


If temperature is a factor in *any* step of your overall operation, quality of its control can affect *several* steps far more than you might expect. And, from our experience with countless applications that may be considered "satisfactory," control is rarely as good as it can be...

Temperature control can be more precise and consistent. It *can* reduce work-stoppage and rejects. It *can* increase volume and maintain quality. It *can* simplify some steps and materially cut costs.

Use the know-how of our world-wide service force to evaluate your potential in temperature control. Free consultation plus complete selection of instruments to suit your individual situation—Veri-Tell Indicators, Gardsman Controllers, Marksman Recorders, our own Thermocouples and accessories.

See us at the 14th Annual Instrument-Automation Conference & Exhibit International Sept. 21-25, 1959 International Amphitheater Chicago Booths 324-326



Marksman Recorders

Model M (shown) potentiometer strip-chart recorder delivers outstanding service and economy through features rarely available in a single instrument. Veri-Tell indicators and Gardsman controllers serve as well. All are tubeless, "solid-state" and proved in wide use. Phone your West consultant (see Yellow pages) or write Chicago office for Bulletin M or for COM digest-catalog of line.

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CIRCLE 124 ON READER-SERVICE CARD

MEASUREMENTS'
***New* VACUUM TUBE VOLTMETER**

MODEL 162

This versatile instrument has been specially designed for voltage and resistance measurements in laboratories, on production lines and in service shops.

- **Push-buttons provide RANDOM ACCESS to all functions and ranges—reducing operator error and fatigue**
- **Balanced degenerative amplifier provides stable zero and good overload protection**
- **Single zero control for all ranges**
- **Compartment for lead and probe storage**

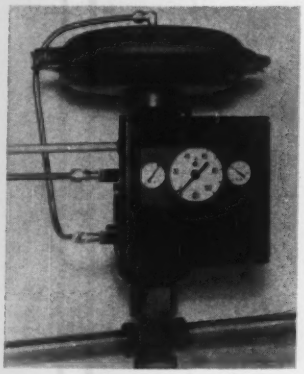
Laboratory Standards WRITE FOR BULLETIN
MEASUREMENTS
A McGraw-Edison Division
BOONTON, NEW JERSEY

CIRCLE 125 ON READER-SERVICE CARD

NEW INSTRUMENTS

PILOT-POSITIONER

New Pilot-Positioner combines a standard USG indicating pilot controller, and a valve positioner. It mounts on the side of any make of diaphragm control valve with stem

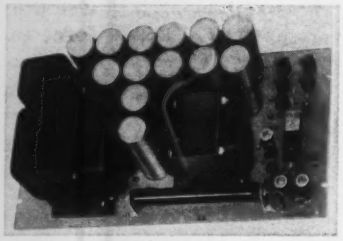


travel from ⅜" to 4". Its measuring elements cover a wide range of pressures and temperatures, or it can be used for pneumatic receiving from a transmitter. It provides a low-cost, yet refined form of control for applications requiring the extra power of a valve positioner.—*U. S. Gauge Div. of American Machine & Metals Inc., Sellersville, Penna.*

CIRCLE 252 ON READER-SERVICE CARD

SOLID-STATE POWER SUPPLY

New solid-state Power Supply for laboratory and instrumentation, Model 738-001, provides an output up to 3



amps at 130 vdc. Efficiency is in excess of 80%, regulation is ±2%; ripple is less than 1% rms.—*U. S. Industries, Inc., Western Design Div., Santa Barbara, Calif.*

CIRCLE 253 ON READER-SERVICE CARD

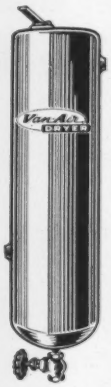
SYNTHETIC INSTRUMENT OIL

New synthetic Anderol L-281 Instrument Oil is a medium-viscosity diester oil for precision instruments with a temperature range from −75°F to +350°F. Completely compatible with ordinary lubricants, it offers penetration comparable to the finest penetrating oils.—*Lehigh Chemical Co., Industrial Lubricants Div., Chestertown, Md.*

CIRCLE 254 ON READER-SERVICE CARD

AIR DRYER

New Van-Air line of Compressed-Air Dryers comprizes 30 sizes with capacities from 1 cfm to 6600 cfm. Features include: (1) sterile (bacteria destroyed), (2) dry (moisture

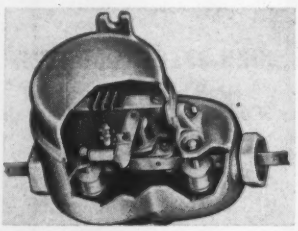


reduced below 0° dewpoint), and (3) clean air (free from gaseous oils and foreign particles down to sub-micronic size). Operates without heat, power, regeneration, injection, or volume loss.—*Van Products Co., 5807 Swanville Rd., Erie, Penna.*

CIRCLE 255 ON READER-SERVICE CARD

ALARM CONTROLLER

New Slack Take Alarm Control, enabling an operator of a remote gaging system to detect immediately a broken tape or any abnormal slack-



ening of the tape, has an idler pulley that rides against the gage tape. When tape breaks or becomes abnormally slack, a mercury switch activates an alarm or any other signal device. May be installed in the field.—*Vapor Recovery Systems Co., 2820 N. Alameda St., Compton, Calif.*

CIRCLE 256 ON READER-SERVICE CARD

VOLTAGE COMPARATOR

New transistorized NLS 50 Go/No-Go Voltage Comparator checks voltage from +0.001 to +999.9 v. Indication of "go" or "no-go" of voltage tolerance is by colored lights. A green "between-limits" lamp shows that the applied voltage lies within the preset limits. Detection threshold is 500 μv.; sensitivity is 0.005%; and limit settings are precise to +0.01%.—*Non-Linear Systems, Inc., Del Mar (San Diego), Calif.*

CIRCLE 257 ON READER-SERVICE CARD

FEEDER CONTROLS

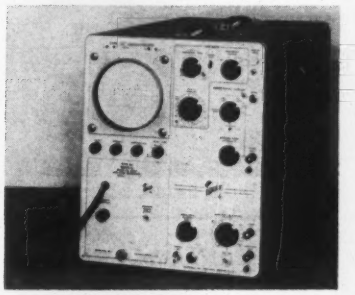
New Controls for Syntron feeders, providing continuous, stepless variable feeding rate adjustments from

0 to 100% capacity, are now standard equipment in the line of electromagnetically vibrated feeders. Also available for feeders already in operation.—*Syntron Co., Lexington Ave., Homer City, Penna.*

CIRCLE 258 ON READER-SERVICE CARD

OSCILLOSCOPES

New Type 581 Oscilloscope (as illustrated) features risetime of 3.5 mμsec, and passband from dc to approximately 100 Mc with Type 80 plug-in preamplifier and probe. Maxi-



mum calibrated deflection factor is 0.1 v/cm; probe attenuator heads provide steps of 0.2, 0.5, 1, 2, and 5 v/cm. Sweeps are calibrated in 24 steps from 0.05 μsec/cm to 2 sec/cm with 5-x magnifier to increase calibrated sweep time to 0.01 μsec/cm.

★ Type 585 has a second time-base generator that acts as a sweep-delay generator, in addition to the identical general specifications. Calibrated sweep delay is continuously adjustable over the range of 1 μsec to 10 sec.—*Tektronix, Inc., P. O. Box 831, Portland 7, Ore.*

CIRCLE 259 ON READER-SERVICE CARD

HIGH-TEMP THERMOCOUPLE

New multiple-shielded Thermocouple Probe, for high-temperature gases moving at velocities in excess

of 100 ft/sec, is protected from radiation losses to the walls. Measures gas temperatures over 1000°F with an accuracy of approximately 5°.—*United Sensor & Control Corp., Box 127, Glastonbury, Conn.*

CIRCLE 260 ON READER-SERVICE CARD

check your process instruments on stream with

NEW W & T

portable, precision pneumatic calibrator

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26 pounds
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sensitive to pressure changes as small as 0.01% of full scale

Accuracy: 0.1% of full range

Standard range: — 1 to 24 p.s.i. other ranges available

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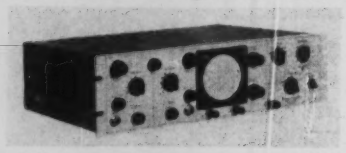
FEEDERS—CIRCLE 127 ON READER-SERVICE CARD

NEW INSTRUMENTS

DOUBLE-BEAM SCOPE

New Double Beam Oscilloscope, Model D31R, features a dual-gun CRT, individual brightness controls,

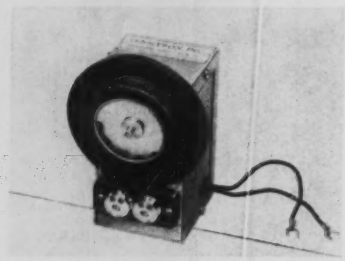


and twin amplifiers dc to 6Mc, -3db, automatic sync, trigger level control and built-in time and voltage calibrators.—*Scopes Co., Inc., P. O. Box 56, Monsey, N. Y.*

CIRCLE 261 ON READER-SERVICE CARD

TENSION WHEEL

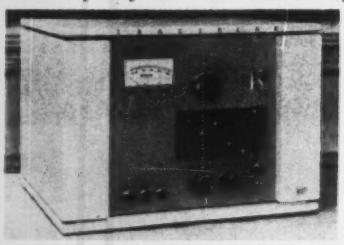
New Tension Wheel is an expandable elastic cover that converts longitudinal motion of the wire into rotary action of a wheel to add tension to wires and heavier textile yarns such as monofilaments, glass yarns and cordage. Wheel is restrained axially by an electric drag device.—*Tensitron Inc., Harvard, Mass.*



CIRCLE 262 ON READER-SERVICE CARD

LOW-COST SCALER

New Auto/Matic, a low-cost Scaler for use with automatic sample changers and Geiger, scintillation, and proportional detectors, features total count capacity of one million by

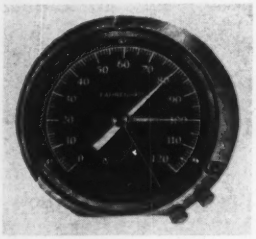


means of six decade scaling circuits composed of a high-speed Magnetron beam switching decade followed by five cold cathode flow-transfer decades. Two models are available: (1) the SC-74V with a high-voltage power supply, and (2) the SC-75 II with a 500-to-2500-v supply.—*Tracerlab, 1601 Trapelo Rd., Waltham 54, Mass.*

CIRCLE 263 ON READER-SERVICE CARD

ALARM THERMOMETERS

New electrical-contact Dial Thermometers, wired for battery or line

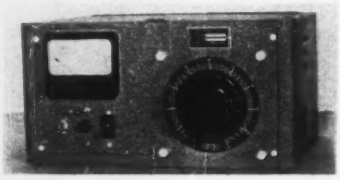


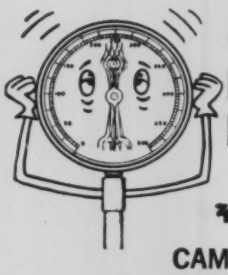
voltage, are available in wide ranges with adjustable single or double contacts.—*Testing Machines, Inc., 72 Jericho Turnpike, Mineola, L. I., N. Y.*

CIRCLE 264 ON READER-SERVICE CARD

HIGH-VOLTAGE TEST SET

New series of light-weight, gas-filled, 50,000 vac Test Sets for dielectric testing in accordance with ASTM





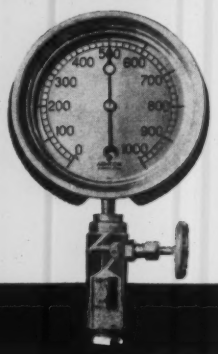
SURE CURE for HEADACHES DUE TO PRESSURE GAUGE JITTERS

CAMPBELL MICRO-BEAN

UNIVERSAL PULSATION DAMPENER

A Campbell Micro-Bean cures a headache ten times as fast as aspirin provided the headache is caused by a pressure gauge with a bad case of the jitters. Rapidly becoming the standard pulsation dampener in many industries all over the world.

Write for Literature–



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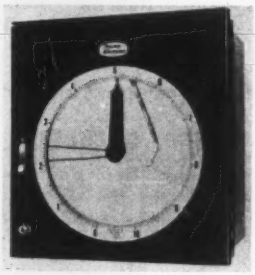
and MIL standards, includes Model KB50-2AC (shown in picture), rated 50 kv at 2 kva. Other voltage and other kva-rated units are available in this series. The non-flammable, non-toxic gas filling functions as a dielectric, coolant, and arc suppressant, and improves reliability.—*Peschel Electronics, Inc., R.F.D. #1., Patterson, New York.*

CIRCLE 265 ON READER-SERVICE CARD

ELECTRONIC RECORDERS AND CONTROLLERS

New Thermo Electronic Indicating Recorders and Indicating Recording Controllers for conductivity, flow,

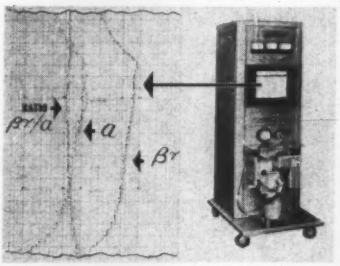


humidity, pressure, temperature, etc. are made as potentiometer- or bridge-types. Accuracy is ±0.25% of scale or 5μv; sensitivity is ±0.125%, uneffected by line voltage fluctuation.—Basic control action is on-off but it can be adapted to three-position control to lag or lead the control setpoint over entire range.—*Thermo Electric Co., Inc., Saddle Brook, N. J.*

CIRCLE 266 ON READER-SERVICE CARD

AIR MONITOR

New Air Monitoring System, permitting immediate identification of long half-life emitters, works on the principle that the ratio of beta-gamma to alpha activity in natural

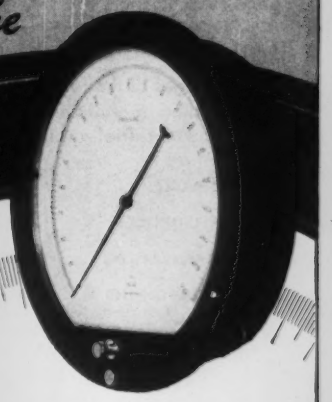


radon-thoron progeny is essentially constant. Available in two types: (1) AM-33R, with moving filter (shown in picture), and (2) AM-22R, with fixed filter. System detects, computes, and records (1) alpha activity, (2) beta-plus-gamma activity, and (3) ratio of beta-gamma to alpha.—*Nuclear Measurements Corp.*, 2460 *N. Arlington Ave., Indianapolis* 18, *Ind.*

CIRCLE 267 ON READER-SERVICE CARD

HEISE GAUGES

The Standard of the World



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The Heise Gauge is a world recognized standard for pressure measurement used by many laboratories in place of the dead weight tester for reference data.

Heise Engineers are always available for advanced research and development. Prompt and skillful attention to inquiries in the precision pressure instrument field is a Heise tradition.

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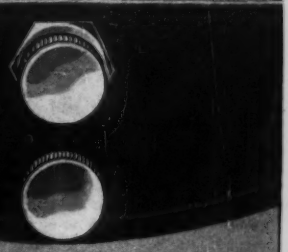

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Range: 0.1 - 20 mm Hg

THE VACUUM GAUGE IN THE MILLIMETER Hg RANGE

Practical - Inexpensive - Stable

Hastings Absolute Pressure Indicator is the first of its class—the finest in its field—and the *only* inexpensive electrical gauge now commercially available that covers the hard-to-measure range of 0.1 to 20 millimeters of mercury.

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- Ideal in applications where "fail-safe" operation is mandatory

Hastings Absolute Pressure Indicator, Model SP-1. Range: 0.1 to 20mm Hg, Expanded Scale from 0.5 to 5mm Hg

Models covering the 5 to 100 millimeters Hg range available on special order.

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VACUUM AND PRESSURE GAUGES

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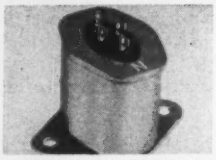
HAMPTON 63, VIRGINIA

CIRCLE 132 ON READER-SERVICE CARD

NEW INSTRUMENTS

OVERHEAT PROTECTORS

New bi-metallic Overheat Protectors, Klixon 9644, for three-phase jet fuel-pump motors up to 1½hp, 200 v,

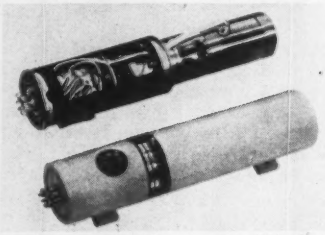


400 cps, react to current as well as temperature. Available in either automatic or non-automatic reset they meet requirements of MIL-E-5272 and the proposed requirements for MIL-P-5238. Bulletin MOPR-11E gives details.—*Metals & Controls Div., Texas Instructions Inc., 34 Forest St., Attleboro, Mass.*

CIRCLE 268 ON READER-SERVICE CARD

GAIN CHANGER

New compact Gain Changer, Type 9805-12, consists of a 115-v, 400-cycle synchronous motor with phase shifting capacitor, coupled thru a 24,000:-

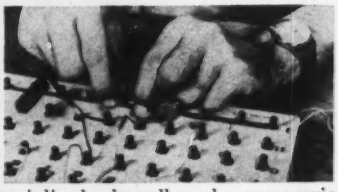


1 ratio gear train; magnetic clutch with associated d-c power supply; and spring reset mechanism for driving a 2-gang potentiometer.—*John Oster Mfg., Co., Avionic Div., One Main St., Racine, Wis.*

CIRCLE 269 ON READER-SERVICE CARD

ELECTRONIC CIRCUIT BOARD

New quick-connect Model 23 Circuit Board for industrial training courses permits rapid assembly and dis-assembly of electrical circuits, using standard components without solder, clips, screw connections or

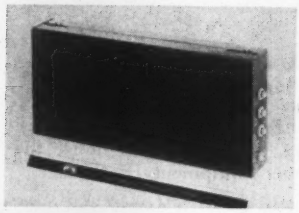


specialized breadboard accessories. Key to board is a unique conductive cell that permits two or more wires to be rapidly connected without use of solder or any type of special connector. Contains 108 conductive cells in a rectangular array.—*Plastic Associates, 185 Mountain Rd., Laguna Beach, Calif.*

CIRCLE 270 ON READER-SERVICE CARD

INSTRUMENTATION AMPLIFIER

New wide-band, completely solid-state, true-differential Instrumentation Amplifier, Redcor Model 261 for



strain gages, thermocouples and other low-signal level devices, has no moving parts.—*Packard-Bell Electronics Corp.*, 12333 *W. Olympic Blvd., Los Angeles* 64, *Calif.*

CIRCLE 271 ON READER-SERVICE CARD

NYLON CABLE TIES

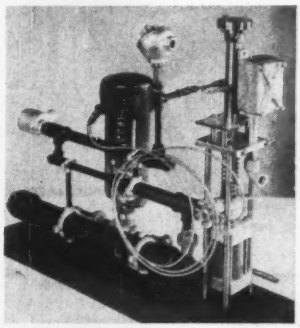
New Lok-Strap Cable Ties feature all-nylon, precision-molded construction. They have excellent electrical

insulating characteristics, high tensile strength, and a service temperature range from −65°F to +300°F. Can replace conventional cable ties for wire harnesses from ⅛" to 1¾" dia.—*Panduit Corp., Dept. IT-5*; 14461 *Waverly Ave., Midlothian, Ill.*

CIRCLE 272 ON READER-SERVICE CARD

CONTROLLED VISCOMETER

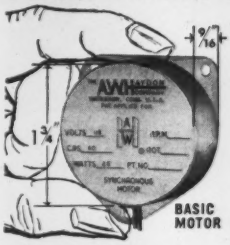
New pipe-line Viscometer has two-stage temperature control. The first stage is self-contained (normally cooling), the second has controlled



heating by an electric temperature controller. Viscosity is measured by a falling piston, and time signals are electrically transmitted for recording or controlling.—*Norcross Corp., Dept.* #45, 247 *Newtonville Ave., Newton* 58, *Mass.*

CIRCLE 273 ON READER-SERVICE CARD

ANOTHER FIRST...



THE ONLY *Electro-Reliable*
A.C. TIMING MOTOR

Thinner... Quieter...
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FINGER-THIN...
Only 9/16 Inches Short... Only 1¾ Inches in Diameter... very compact... reduces the size of your equipment.

WHISPER-QUIET...
Strictly an electrical motor..., practically noiseless... no rattling of gears or ratchets.

HIGH TORQUE...
¼ oz. inch at the rotor with an instantaneous start and stop... requires only 2½ watts... can replace larger motors in recorders, controls and telemetering equipment.

HIGHEST RELIABILITY...
Longer life... no one-way gears or ratchets to fail... provides millions of operations without any trouble.

Send for Special Illustrated Bulletin AWH MO-806

SPECIFICATIONS

Standard Voltage Ratings: 6, 12, 24, 115, 230 Volts
Frequency: 60 CPS Standard; 25, 50 CPS Available
Power Input: 2.5 Watts Maximum (60 CPS)

BASIC MOTOR
Weight: 4 ounces
Speed: 300 RPM
Torque: ¼ oz-in.
Length: 9/16 inch

WITH INTEGRAL GEAR TRAIN
Weight: 5 ounces
Speed: 300 RPM to 1/6 RPH
Torque: 30 oz.-in. @ 1 RPM
Length: ⅞ inch

WITH INTEGRAL GEAR TRAIN

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Custom Design & Manufacture Of Electronic And Electro-Mechanical Timing Devices

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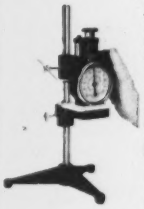
SCLEROSCOPE
FOR TESTING THE HARDNESS OF METALS. PIONEER AMERICAN HARDNESS STANDARD. OVER 40,000 IN USE. (ASTM A427)



DUROMETER
FOR TESTING THE HARDNESS OF RUBBER & RUBBER-LIKE MATERIALS (ASTM D676) (ASTM D1484)

SHORE INSTRUMENT & MFG. CO., INC.
90-35 VAN WYCK EXP.
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T LAMINATED & SOLID GLASS **FILTERS**
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WINDOWS • PRISMS • WEDGES

F SPECIALIZED GLASS
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TOLERANCES TO .0001"

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ON ALL TYPES OF GLASS & CERAMICS

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AUTOMATIC SCREW MACHINES TO 4" DIA. — ALSO HAND SCREW MACHINES — ENGLISH & METRIC THREADS OUR SPECIALTY.

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TIFFEN OPTICAL CO.
INDUSTRIAL DIVISION
71 Jane St., Roslyn Heights, L.I., N.Y.

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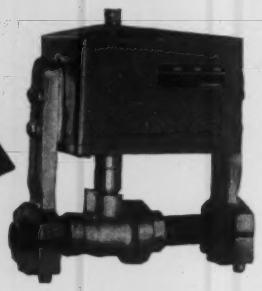
Compact High Torque Control!

LOW ORIGINAL COST!
EASY INSTALLATION!

Quickly Installed on Existing Valves Without Disturbing Piping.

R & A Electric Ball or Plug Valve Actuator



Provides positive automatic control at any distance, yet allows manual over-ride in event of power failure. Standard unit 110 volt 60 cycle AC. Stock models: 325, 650, 1200, 2400 in. lbs. Universal mounting bracket for various ranges of pipe sizes. Explosion-proof models; higher torque models; units for other AC and DC voltages and frequencies available on request.

FOR PRICE LIST AND DESCRIPTIVE MATERIAL, WRITE OR CALL

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NEW! CUSTOM GRADE CONSOLES AT LOW STOCK PRICES!

GENCO CABINETS & PANELS

* fit your space exactly
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* protect costly, fragile instruments

Now consoles, instrument panels, cabinets don't have to be either expensive custom installations or cheap stock items. **GENCO** brings you the benefits of each . . . custom-made at little more than stock prices.

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Rush my copy of new GENCO brochure.
Have your representative call.

Name.....
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CIRCLE 137 ON READER-SERVICE CARD

new plants and mergers

HAGAN CHEMICALS & CONTROLS has started work on a 25,000-sq-ft addition to its research center.

COMPTOMETER CORP. has leased a 100,000-sq-ft one-story building in Niles, Ill., which will house the R&D and the Communications Equipment Divisions.

MARKITE CORP. announces that **SANDYNAMICS, INC.** has been licensed to produce its precision potentiometers, and that the newly-formed **MARKITE PRODUCTS CORP.**, 155 Waverly Place, New York 14, N. Y. will handle all sales.

NARDA ULTRASONIC CORP. has just expanded into a new 10,000-sq-ft building adjoining the main plant.

ENGELHARD INDUSTRIES announces that **CHARLES ENGELHARD, INC.** has become the parent company's Instruments and Systems Division.

ASSOCIATED CONTROL EQUIPMENT, INC. was recently formed in Coraopolis, Pa. by *Charles A. Dally III* to provide inventors of control devices with a manufacturing and marketing outlet.

ROBINSON TECHNICAL PRODUCTS has acquired all of the outstanding shares of **HIGH VACUUM EQUIPMENT CORP.** and will operate it as a wholly-owned subsidiary.

HIGH-PRECISION ball & dis integrato

$90.00
MODEL 219 with standard control rod

Highest accuracy and reproducibility at lowest cost. Smooth, reliable operation for precise integration and control applications such as flow totalization, speed control, strain analysis or continuous weighing.

Write for complete engineering and applications data.

ACCURACY: ±0.1%
REPRODUCIBILITY: ±0.01%
OUTPUT TORQUE: 3 oz.-in. (higher outputs at reduced accuracy)
INPUT TORQUE: 2 oz.-in. (no output load)
CONTROL ROD: Vernier, rack, screw, or plain. Special rods designed to specification
CONTROL ROD FORCE: 3 oz. static 1 oz. dynamic
INPUT SPEED: 0-750 rpm
OUTPUT SPEED: Reversible up to more than twice the input

REFLECTONE

THE REFLECTONE CORP. • STAMFORD, CONN.

CIRCLE 138 ON READER-SERVICE CARD

ASSEMBLY PRODUCTS' new 9600-sq-ft manufacturing area is slightly pressurized, like an airplane cabin, to minimize dust infiltration.

ELECTRO-MECHANICAL RESEARCH, INC (EMR) has purchased all of the assets of **APPLIED SCIENCE CORP. OF PRINCETON** (ASCOP) which will be managed as a division of EMR. EMR is a wholly-owned subsidiary of **SCHLUMBERGER LTD.**

POTTER & BRUMFIELD, INC. and **THOMPSON-BREMER & CO.**, formerly subsidiaries of **AMERICAN MACHINE & FOUNDRY**, have been made divisions of the company.

HOFFMAN ELECTRONICS' Semiconductor Div. has opened an area sales engineering office in San Diego.

GULTON INDUSTRIES' new sales division. Glennite Battery Distributors, has named **GENERAL TRANSISTOR DISTRIBUTING CORP.** national distributor for rechargeable VO-Series batteries.

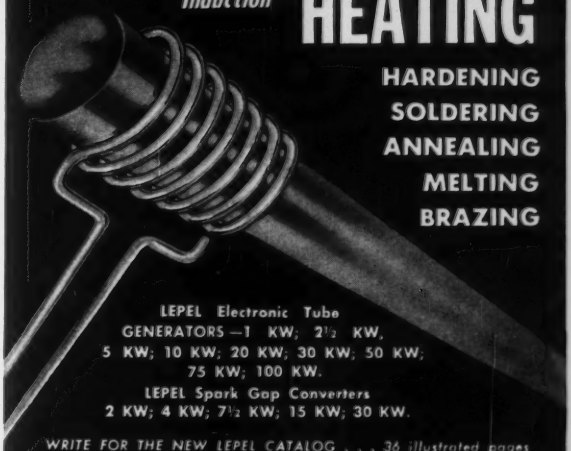
HEWLETT-PACKARD has purchased all of the outstanding stock of **BOONTON RADIO CORP.**, which will be operated as a wholly-owned subsidiary.

Lepel

HIGH FREQUENCY

Induction HEATING

HARDENING
SOLDERING
ANNEALING
MELTING
BRAZING



LEPEL Electronic Tube GENERATORS—1 KW; 2½ KW, 5 KW; 10 KW; 20 KW; 30 KW; 50 KW; 75 KW; 100 KW.

LEPEL Spark Gap Converters 2 KW; 4 KW; 7½ KW; 15 KW; 30 KW.

WRITE FOR THE NEW LEPEL CATALOG . . . 36 illustrated pages packed with valuable information.

All Lepel equipment is certified to comply with the requirements of the Federal Communications Commission.

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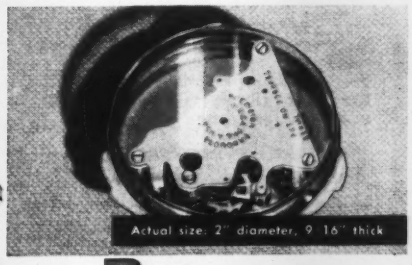
If you operate or make timers, use...



PRECISION ESCAPEMENTS

Compact PRECISION timing governors (escapements) are especially applicable to installations where space is limited.

Over 800,000 PRECISION built governors are in daily use all over the country in timing devices of many kinds.

Find out about these units or our capacity to make a special one for you.

Write for literature or send us specifications for the governor you need.

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MARSHALLTOWN

THE RIGHT GAUGE FOR YOUR SPECIFIC NEEDS

Available in a wide variety of general purpose and special purpose gauges in pressure ranges to meet your specifications in every particular.

- PRESSURE
- VACUUM
- COMPOUND
- ALTITUDE
- COMBINATION
- DIAPHRAGM
- HYDRAULIC
- AND SPECIAL PURPOSE GAUGES
- DIAL THERMOMETERS (Vapor Tension or Bi-Metal)

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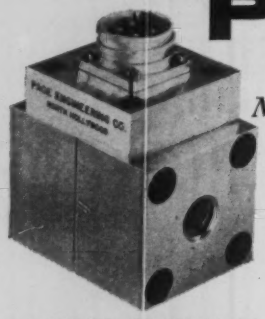
CIRCLE 141 ON READER-SERVICE CARD

PACE



Magnetic Reluctance

PRESSURE TRANSDUCER MODEL P3D

RANGES AS LOW AS ±1/10 PSID
MAXIMUM LINE PRESSURE 5000 PSI

- **MAXIMUM OVERPRESSURE:** 200 psid or 200% range.
- **EXTREMELY CORROSION RESISTANT.**
- **INSENSITIVE TO SHOCK AND VIBRATION—** not oil filled.
- **ACCEPTS CORROSIVE FLUIDS BOTH SIDES—** all stainless exposure.

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GALLIUM ANTIMONIDE
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GARNET
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CIRCLE 143 ON READER-SERVICE CARD

people in the news

F. R. Bradley
Analogue Controls

P. L. Bealer
Telecomputing

P. F. Pagerey
Taylor Instr.

ANALOGUE CONTROLS announces election of *Frank R. Bradley* to succeed *Karl Birken* as president.

TELECOMPUTING CORP. announces promotion of *Peter L. Bealer* to director of advertising.

TAYLOR INSTRUMENTS COS. have named *Dr. Paul F. Pagerey* as research director.

NBS announces that *Dr. Francis B. Silsbee* has retired after 48 years with the Bureau.

PHILCO's Government & Industrial Div. announces promotion of *William Doherty* to sales manager for Transac computers.

LEEDS & NORTHRUP announces appointments of *Edwin D. Scutt* and *S. Byron Morehouse* to the new positions of assistant to vice president—marketing.

NATL. ASSN. OF RELAY MFRS. announces election of *John L. Pfeffer*, president of STRUTHERS-DUNN, to president of the association.

King MANOMETERS

For Plant and Laboratory

King Manometers are rugged, low-cost instruments of unexcelled accuracy for measuring pressure, vacuum, differential pressure, and pressure-related phenomena. They're available in the following types, in a complete range of sizes:

U-Type Manometers

- Single Cleanout
- Double Cleanout
- With 3-Valve Manifold
- Inverted U-Type

Well-Type Manometers

- Low-well
- Raised-Well
- Adjustable-Well
- Barometric-Reading
- Flowmeter Type
- Inclined-Tube

Multi-Tube Manometers

- Individual-Well
- Common-Well
- Photo-Manometers

NEW CATALOG 2008 gives details on these and other models—includes manometer liquids and accessories—explains basic principles. Write—

KING INSTRUMENT

KING ENGINEERING CORP.
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REPRESENTATIVES IN PRINCIPAL CITIES

CIRCLE 144 ON READER-SERVICE CARD

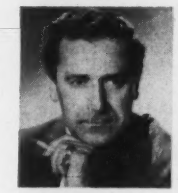
F. J. Larsen
M-H

G. E. Fickett
Powers

H. G. Mellen
Photomation

F. Hugel
Dynametrics

H. M. Byrnes
SAMA



V. W. Farris
Farris Engr.

MINNEAPOLIS-HONEYWELL has named *Dr. Finn J. Larsen* to the newly-created post of vice president in charge of research.

POWERS REGULATOR CO. has elected *George E. Fickett* vice president and general sales manager.

PHOTOMATION, INC. announces appointment of *Howard G. Mellen* as sales and marketing engineer.

DYNAMETRICS CORP. announces promotion of *Fred Hugel* to manufacturing director.

SAMA announces that *H. M. Byrnes* has been named executive secretary of the Recorder-Controller Section.

FARRIS ENGINEERING CORP.'s president *Victor W. Farris* was among eleven men who recently were honored by Free Enterprise Awards Association's American Success Story Awards.

HICKOK ELECTRICAL INSTRUMENT CO., manufacturer of electronic test equipment and electrical indicating meters, announced appointment of *J. W. (Jack) Siringer* as advertising manager.

AMERICAN METER has named *Harold W. Wahl* manager of the Southwest Division.

HUGHES AIRCRAFT announces that *Richard L. Lawrence* has been appointed manager of advertising and sales promotion for the Semiconductor Division.

CROSBY VALVE & GAGE announces appointment of *William E. Mikolasy* as sales manager, eastern districts.

MIDWESTERN INSTRUMENTS announces appointment of *William E. Seaman* as chief engineer.

SAMA has cited *Lawrence L. Melick* for "outstanding service and contribution to both government and industry. Recruited by SAMA, Mr. Melick had been loaned from Bailey Meter Co. to serve in Washington.

U. S. GAUGE announces appointment of *R. E. Cassidy* as director of process instrumentation training.

FOXBORO COMPANY announces appointment of *R. F. Sutton* as branch manager at Philadelphia; *T. A. Jones* has been named to the same post in Atlanta.

INTELEX SYSTEMS a subsidiary of ITT, has elected *Neil M. Blair* vice president and assistant to the president.

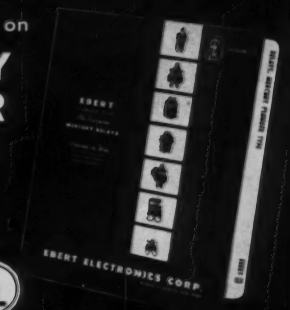
LOCKHEED's new Electronics and Avionics Div. announces appointment of *M. Carl Haddon* as its general manager and a vice president of the company.

FREE ENGINEER'S FACT FILE

A Complete Manual on

MERCURY PLUNGER RELAYS

For all loads up to 60 Amps or 5 H.P.



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FREE: Brand new edition, fully illustrated. Rated as the standard reference manual on all types and applications of Mercury Plunger Relays. 1, 2 and 3 pole hermetically sealed, compact and miniature units that provide millions of continuous makes and breaks without maintenance. No pitting or corrosion.

Send for FREE FACT FILE and 30-day Free Test details.

EBERT ELECTRONICS CORP.

212-A8 Jamaica Ave., Queens Village 28, N. Y.

CANADA: Philips Electronics Industries Ltd., 116 Vanderhoof Ave., Toronto 17

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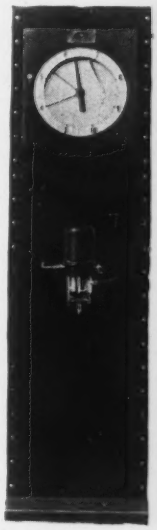

Single-Point pH Recorder (Strip Chart Assemblies also available)

CAMBRIDGE pH INDICATORS and RECORDERS

Labor saving—profit producing!

In addition to portable pH meters, Cambridge makes line-operated Direct Reading pH Indicators and Recorders for permanent installation. They are accurate, stable and assure continuous and trouble-free performance. Either the Recorder, Indicator or both, may be located at any reasonable distance from one or several sampling points. The Glass Electrodes are placed in vapor-tight housings of clog-free sampling chambers.

Send for Bulletin No. 910 T

CAMBRIDGE pH EQUIPMENT

CAMBRIDGE INSTRUMENT CO., INC.

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PIONEER MANUFACTURERS OF PRECISION INSTRUMENTS

CIRCLE 146 ON READER-SERVICE CARD

miniaturized *bh** gauges

*Miniaturized **bourdon helix** gauges, pioneered by Glassco Instrument Company, have only one moving part. No gears, no linkage, they offer exceptional performance and reliability with minimum space and weight, plus design flexibility to meet unusual specifications.

For details, write for Bulletin G-1003

Glassco

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CIRCLE 147 ON READER-SERVICE CARD

FREED

VARIABLE TEST VOLTAGE MEGOHMMETER NO. 1620

The Freed Type 1620 Megohmmeter is a versatile insulation resistance measurement instrument with a continuously variable DC test potential from 50 to 1000 volts.

Components such as transformers, motors, printed circuits, cables and insulation material can be tested at their rated voltage and above, for safety factor.

- Resistance — 0.1 megohms to 4,000,000 megohms.
- Voltage — variable, 50 - 1000 volts.
- Accurate — plus or minus 5% on all ranges.
- Simple — for use by unskilled operators.
- Safe — high voltage relay controlled.
- Self contained — AC operated.

OTHER MEGOHMMETERS AVAILABLE

Type 1620C MEGOHMMETER — a type 1620 with additional circuitry for testing capacitors.
Type 1020B MEGOHMMETER — a 500 volt fixed test potential. Range 1 megohm to 2 million megohms.
Type 2030 PORTABLE MEGOHMMETER — battery operated 500 volt test potential. Range 1 megohm to 10 million megohms.

Send for NEW 48 page transformer catalog. Also ask for complete laboratory test instrument catalog.

FREED TRANSFORMER CO., INC.

1707 WEIRFIELD ST., BROOKLYN (RIDGEWOOD) 27, N.Y.

CIRCLE 148 ON READER-SERVICE CARD

new literature

CONTROL SYSTEMS

TUNNEL KILN INSTRUMENTATION. 4-page Bulletin DM054 describes pyrometers in controlling, recording and indicating models; draft controllers and recorders; and thermocouple and radiation sensing units.—Bristol Co., Waterbury 20, Conn.

CIRCLE 274 ON READER-SERVICE CARD

PROCESS INDUSTRIES EQUIPMENT. 8-page Bulletin B-I-F 5-1 illustrates and describes equipment, systems, and controls for the process industries.—B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R. I.

CIRCLE 275 ON READER-SERVICE CARD

SELECTOR STATION. 4-page Product Specification P99-1 describes selector station for remote manual trimming of pneumatic control systems, and for transferring from automatic to manual operation.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

CIRCLE 276 ON READER-SERVICE CARD

SYSTEM ANALYZER. 8-page bulletin describes a system analyzer to test up to 2600 circuits, and gives detailed information on all units of equipment.—Technical Electronics Corp., 4060 Ince Blvd., Culver City, Calif.

CIRCLE 277 ON READER-SERVICE CARD

WATER and WASTE TREATMENT. 16-page Bulletin 1100-B describes "C.-A.-P. System" instruments for flow, level, and pressure measurement and control in filter plants, etc.—Infilco Incorporated, P. O. Box 5033, Tucson, Ariz.

CIRCLE 278 ON READER-SERVICE CARD

HYDRAULIC DAMPER REGULATOR. 2-page catalog sheet describes Type 5000 damper regulator which also regulates fans, stokers, oil and gas control valves.—Atlas Valve Co., 280 South St., Newark, N. J.

CIRCLE 279 ON READER-SERVICE CARD

TEMPERATURE

MERCURY BULB ELEMENTS. 4-page Bulletin 851 gives full description on basic principle, types, temperature ranges, etc. of solid-filled bulb-and-head assemblies.—Partlow Corp., New Hartford (Utica), N. Y.

CIRCLE 280 ON READER-SERVICE CARD

LOW-TEMPERATURE TECHNIQUE. 44-page booklet discusses developments in low-temperature chemistry, solid-state physics, superconductivity, metallurgical research, maser research, microwave spectrometry, etc.—Hofman Laboratories, Inc., 5 Evans Terminal, Hillside, N. J.

CIRCLE 281 ON READER-SERVICE CARD

MINIATURE CONTROLS. 4-page brochure MC-182 contains descriptions of nineteen different midget and miniature Thermoswitch controls.—Fenwal Inc., Ashland, Mass.

CIRCLE 282 ON READER-SERVICE CARD

HIGH-TEMP THERMOCOUPLE WIRE. 8-page brochure contains data on metallic sheeted AerOpak thermocouple wire, also electrical conductors, heating elements, and thermocouples. Aero Research Instrument Co., 315 N. Aberdeen St., Chicago 7, Ill.

CIRCLE 283 ON READER-SERVICE CARD

RESISTANCE THERMOMETERS. 6-page Catalog T59 provides complete data on line of resistance thermometer elements.—Arthur C. Ruge Associates, Inc., Hudson, New Hampshire.

CIRCLE 284 ON READER-SERVICE CARD

VALVES

HYPRESPHERE VALVES. 10-page Bulletin V-607, Rev. 1, describes Rockwell's Hypresphere line of full-opening, lubricated spherical plug valves.—Rockwell Mfg. Co., Meter and Valve Div., 400 North Lexington Ave., Pittsburgh 8, Pa.

CIRCLE 285 ON READER-SERVICE CARD

FOUR-WAY AIR VALVES. 4-page Bulletin 235 covers the alternate bases and integral speed control section for Series "CC" 4-way directional air control valves.—Hannifin Co., Dept. 302, 501 South Wolf Rd., Des Plaines, Ill.

CIRCLE 286 ON READER-SERVICE CARD

ECCENTRIC-PLUG VALVES. 20-page Bulletin 150 lists valve bodies and actuators, and the accessory line available for DeZurik control valves.—DeZurik Corp., Sartell, Minn.

CIRCLE 287 ON READER-SERVICE CARD

VALVES FOR NUCLEAR & CHEMICAL INDUSTRIES. 190-page Bulletin A-155 gives complete data on line of valves for a wide variety of nuclear and chemical applications.—Associated Valve Co., 337 West Walnut St., North Wales, Penna.

CIRCLE 288 ON READER-SERVICE CARD

PRESSURE, VACUUM WEIGHT

VERTICAL-SCALE INDICATOR. 4-page Specification Sheet 59-B214 contains specs on Model 214 indicator unit for pressure, draft, flow, and temperature.—Hays Corp., Michigan City, Ind.

CIRCLE 289 ON READER-SERVICE CARD

VACUUM TECHNIQUE. 8-page "Vacuum Reports No. 2" contains illustrations of vacuum equipment and reports on its applications.—Kinney Mfg. Div., New York Air Brake Co., 3529 Washington St., Boston 30, Mass.

CIRCLE 290 ON READER-SERVICE CARD

CHECKWEIGHER. 4-page folder, Form 2968, illustrates and describes features and advantages of the Model 9460 automatic checkweigher.—Toledo Scale, Div. of Toledo Scale Corp., Toledo 12, Ohio.

CIRCLE 291 ON READER-SERVICE CARD

PRESSURE PICKUPS. 2-page Bulletin 107 describes and specifies Series P3600 pressure pickups.—Wiancko Engineering Co., 255 N. Halstead, Pasadena, Calif.

CIRCLE 292 ON READER-SERVICE CARD

TIME, COUNT

REMOTE IMPULSE COUNTERS. 2-page data sheet illustrates and describes the TCeB series of electric impulse counters.—Landis & Gyr, Inc., 45 West 45th St., New York 36, N. Y.

CIRCLE 293 ON READER-SERVICE CARD

STOPWATCHES. 24-page catalog illustrates and specifies more than 90 different types of Swiss-made stopwatches for time-and-motion study, and sports.—Heuer Timer Corp., 441 Lexington Ave., New York 17, N. Y.

CIRCLE 294 ON READER-SERVICE CARD

CLOCK AND INTERVAL TIMERS. 2-page bulletin GEA-6804 describes interval and combination clock-interval timers, series AMT-1 for gas and electric ranges.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 295 ON READER-SERVICE CARD

SWINGING-HEAD COUNTER. 2-page product sheet describes how the counter's two separate sets of plus and minus print wheels are geared to assure smooth transfer from positive to negative values without possibility of losing a digit.—American Data Div., American Electronics, Inc., 75 Front St., Brooklyn 1, N. Y.

CIRCLE 296 ON READER-SERVICE CARD

AIR, STEAM

DE-HUMIDIFIER. 4-page Bulletin No. 140 describes the Hygrol air dehumidifier which uses a liquid absorbent for drying air.—Niagara Blower Co., 405 Lexington Ave., New York 17, N. Y.

CIRCLE 297 ON READER-SERVICE CARD

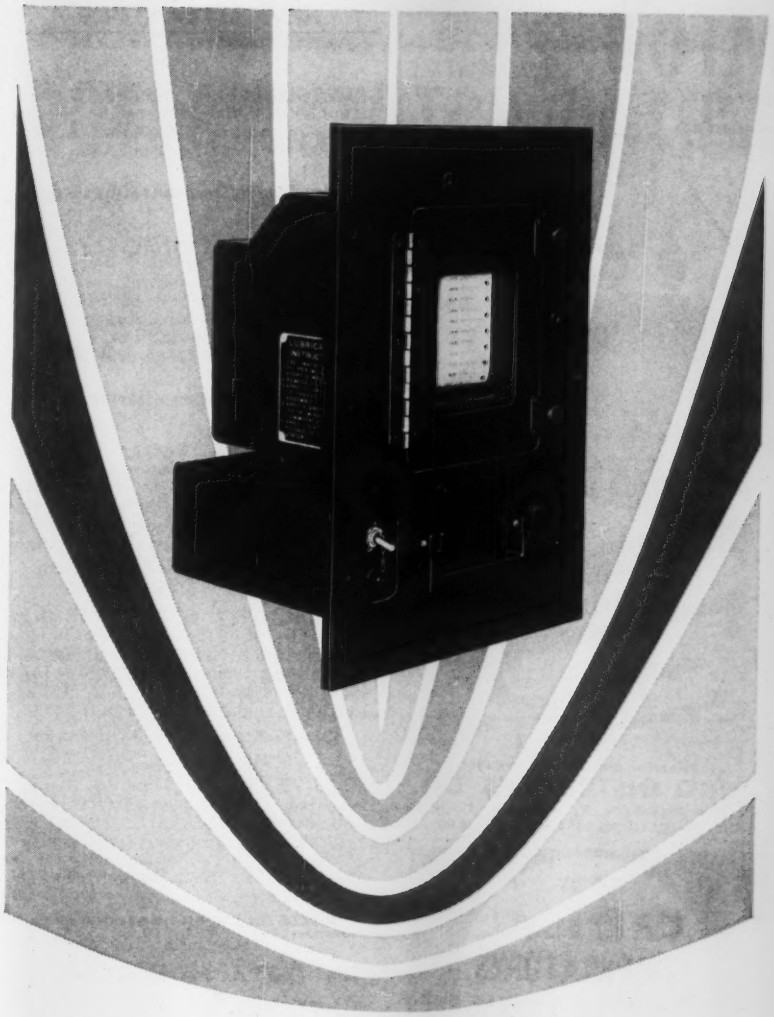
CONDENSATE METERS. 4-page Folder 1000 describes and illustrates rotary condensation meters and their application on gravity- or vacuum-systems to measure steam consumption.—L-R-P, Inc., Leicester, N. Y.

CIRCLE 298 ON READER-SERVICE CARD

VIBRATION

SHOCK TESTER. 4-page Bulletin 4-71 explains in detail the features, the acceleration and deceleration system, shock pulses, etc. of HY-6500 shock tester.—Consolidated Electrodynamics Corp., Rochester Div., 1775 Mount Read Blvd., Rochester 3, N. Y.

CIRCLE 299 ON READER-SERVICE CARD



NEW CLARY MILITARIZED PRINTER

WITHSTANDS 50G SHOCK!

The new Model 2000 series printers designed by Clary will print digital data even under the extreme environmental conditions encountered in military use • These rugged, reliable printers are constructed on a sturdy panel for vertical rack mounting, and contain all necessary electronic equipment for data decoding, digit selection, and control functions of the printer • They are designed to print the output from computers, digital voltmeters, shaft position transducers, electronic counters and digital clocks. In addition, they are ideal in industrial applications where continuous, unfailing operation is required • For complete information on how Clary Model 2000 series can help you, write today for Engineering Bulletin S-120 •

Clary

Electronics Division

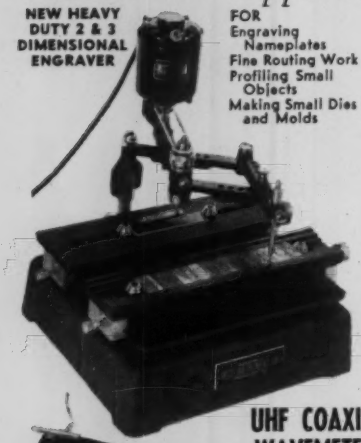
San Gabriel, California

CIRCLE 149 ON READER-SERVICE CARD

MICO *Precision Apparatus*

NEW HEAVY DUTY 2 & 3 DIMENSIONAL ENGRAVER

FOR
Engraving Nameplates
Fine Routing Work
Profiling Small Objects
Making Small Dies and Molds



UHF COAXIAL WAVEMETERS

2-75 Centimeter Range

Send for Illustrated Catalogs

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86 Trowbridge St., Cambridge 38, Mass.

CIRCLE 150 ON READER-SERVICE CARD

SPOT **CRITICAL TEMPERATURES ACCURATELY** with

NEW PYRO MICRO-OPTICAL PYROMETER

All-purpose PYRO Micro-Optical precisely measures targets as small as .001" in diameter or objects at remote distances to 2°C reproducibility! Temperature scales 700° - 3200°C (1300° - 5800°F).

Send for FREE catalog No. 95.

PYROMETER INSTRUMENT CO., INC.

BERGENFIELD 4, NEW JERSEY

CIRCLE 151 ON READER-SERVICE CARD

NEW LITERATURE

SOUND ISOLATION ROOMS. 2-page pamphlet describes and specifies sound isolation rooms.—Industrial Acoustics Co., Inc., 341 Jackson Ave., New York 54, N. Y.

CIRCLE 300 ON READER-SERVICE CARD

NUCLEONICS

DENSITY GAGE. 2-page Bulletin LSG describes the method of operation, specifications and advantages of the Model LSG gamma radiation gage.—Ohmart Corp., 2236 Bogen St., Cincinnati 22, Ohio.

CIRCLE 301 ON READER-SERVICE CARD

PREAMPLIFIERS. 2-page brochure, Form 3023-9, covers five separate preamplifiers for use with scintillation, proportional counter, or GM tube detectors.—Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.

CIRCLE 302 ON READER-SERVICE CARD

RADIOACTIVITY MONITOR. 16-page Bulletin M-59 describes monitoring systems for detecting, measuring, and recording radioactivity.—Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.

CIRCLE 303 ON READER-SERVICE CARD

MASSIVE PLASTIC FLUORS. 4-page booklet describes chemical composition, scintillation characteristics and typical applications of solid solution plastic fluor.—Cadillac Plastic & Chemical Co., 15111 Second Ave., Detroit 3, Mich.

CIRCLE 304 ON READER-SERVICE CARD

DATA HANDLING

DIGITAL COMPUTER. 6-page Bulletin AB-059 fully describes and specifies the G-15 general-purpose digital computer and its accessories.—Bendix Computer Div., Bendix Aviaton Corp., 5630 Arbor Vitae St., Los Angeles 45, Calif.

CIRCLE 305 ON READER-SERVICE CARD

COMPUTER APPLICATION. 4-page Bulletin S516 (LGP-30 Application Report #12) describes how Simpson Optical Mfg. Co. is using the Royal Precision LGP-30 electronic computer to design new optical devices.—Royal McBee Corp., Port Chester, N. Y.

CIRCLE 306 ON READER-SERVICE CARD

ANALOG COMPUTERS. 4-page short-form catalog describes various analog computing instruments.—George A. Philbrick Researches, Inc., 285 Columbus Ave., Boston 16, Mass.

CIRCLE 307 ON READER-SERVICE CARD

DATA TRANSMISSION. 16-page issue of "Technical News Bulletin," Vol. 2/No. 5 contains an article on "High Accuracy Resolvers."—Kearfott Co., Inc., 1500 Main Ave., Clifton, N. J.

CIRCLE 308 ON READER-SERVICE CARD

PLUG-INS FOR DIGITAL SYSTEMS. 6-page Catalog PI-79 contains detailed physical and electrical specifications of Dykor transistorized plug-in units for digital systems.—Dykor Components Div., Digitronics Corp., Albertson, L. I., N. Y.

CIRCLE 309 ON READER-SERVICE CARD

LIGHT FOOT QUANTIZER. 2-page Bulletin 104 describes the Light Foot Quantizer, a device capable of time resolution to 20 mμsec.—Computer Equipment Corp., 1931 Pontius Ave., Los Angeles 25, Calif.

CIRCLE 310 ON READER-SERVICE CARD

RECORDING

RECORDING SYSTEMS. 4-page Catalog Sheet 1684A illustrates, describes, and specifies 6- and 8-channel recording systems Model 1684.—Brush Instruments, Div. of Clevite Corp., 37th & Perkins, Cleveland 14, Ohio.

CIRCLE 311 ON READER-SERVICE CARD

STRAIN GAGE RECORDER. 2-page Bulletin 350-4 contains description and specifications of strain gage digital data recording system.—Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

CIRCLE 312 ON READER-SERVICE CARD

PHOTOINSTRUMENTATION. 4-page issue of "Recorder," Vol. 2/No. 1, features an article on "The Basic Principles of Automatic Exposure Control."—Flight Research, Inc., P. O. Box 1-F, Richmond 1, Va.

CIRCLE 313 ON READER-SERVICE CARD

CONTROL STATIONS. Two specification sheets, 51-1202W-1 (2 pages), and 51-1212W-1 (4 pages), describe Mark III four-inch strip chart miniature recording and recording control stations for process variables.—Fischer & Porter Co., 217 Jacksonville Rd., Hatboro, Penna.

CIRCLE 314 ON READER-SERVICE CARD

TESTING, GAGING

ENVIRONMENTAL TEST CHAMBERS. 8-page Bulletin G-58 contains illustrations and specs of temperature, explosion, humidity, and other test chambers.—Missimers Incorporated, 3206 Los Felix Blvd., Los Angeles 39, Calif.

CIRCLE 315 ON READER-SERVICE CARD

DIAL INDICATORS. 4-page brochure describes the Federal Miracle-Movement dial indicator.—Federal Products Corp., 1144 Eddy St., Providence 1, R. I.

CIRCLE 316 ON READER-SERVICE CARD

ELECTRONIC MICROMETER. 2-page Bulletin 4007 details full specs and data of Model PDR automatic electronic micrometer.—J. W. Dice Co., Englewood, N. J.

CIRCLE 317 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC INSTRUMENTS

DYNAMIC MEASUREMENTS. 16-page General Catalog, Bulletin 1310, of the Electro Mechanical Instrument Div., contains descriptions of oscillographs, data amplifiers, and bridge balances; vibration measuring equipment; and power supplies.—Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

CIRCLE 318 ON READER-SERVICE CARD

PHASE METERS. 2-page bulletin describes and specifies Type 405 Series precision phase meters for measuring phase angles between two alternating voltages without either amplitude or frequency adjustment.—Ad-Yu Electronics Lab., Inc., 249 Terhune Ave., Passaic, N. J.

CIRCLE 319 ON READER-SERVICE CARD

DIGITAL VOLTMETER. 4-page Bulletin 309 describes a new series of digital voltmeters and multiple meters.—Franklin Electronics Inc., Bridgeport, Penna.

CIRCLE 320 ON READER-SERVICE CARD

ELECTRONIC GALVANOMETER. 2-page Bulletin L-53S describes rack-mounting electronic galvanometer and gives electrical specs.—Shallcross Mfg. Co., Selma, N. C.

CIRCLE 321 ON READER-SERVICE CARD

POWER METERS. 6-page issue of "PDR Reporter," Vol. 6/No. 3 features an article on "Dry Calorimetric Power Meters."—Polytechnic Research & Development Co., Inc., 202 Tillary St., Brooklyn 1, N. Y.

CIRCLE 322 ON READER-SERVICE CARD

ELECTRICAL SIDE INDICATORS. 2-page Bulletin 2601 provides complete information, specifications and dimensions on electrical side indicators.—International Instruments Inc., P. O. Box 2954, New Haven 15, Conn.

CIRCLE 323 ON READER-SERVICE CARD

ELECTRONIC EQUIPMENT. 2-page short-form catalog illustrates and specifies precision electronic equipment such as phase meter, null meter, power oscillators, null detector, etc.—Industrial Test Equipment Co., 55 East 11th St., New York 3, N. Y.

CIRCLE 324 ON READER-SERVICE CARD

RECTIFIERS FOR PLATING. 16-page pocket-size Bulletin 100 contains sketches and descriptions of selenium, germanium, and silcon rectifier units for electroplating and anodizing.—Djeco Div. of Djordjevic Engineering Co., 1933 N. Damen, Chicago 47, Ill.

CIRCLE 325 ON READER-SERVICE CARD

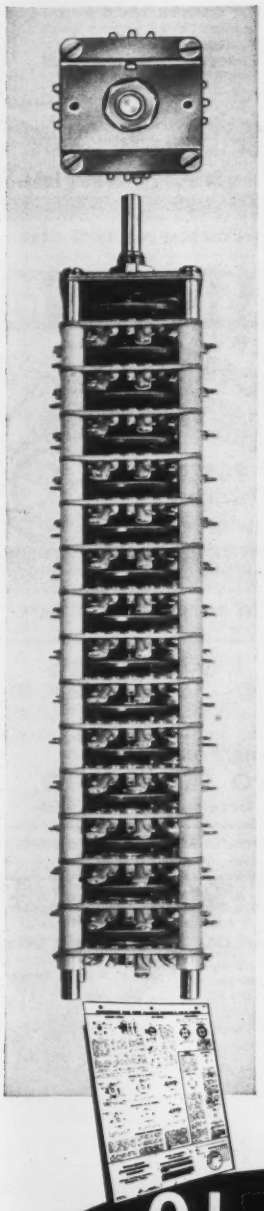
ITV

VIDEO SWITCHING SYSTEM. 2-page Bulletin 6-99 describes the AVS-X System used in ITV circuits to switch a number of television cameras to any of a number of TV viewing monitors.—Kin Tel Div., Cohu Electronics, 5725 Kearny Villa Rd., San Diego 12, Calif.

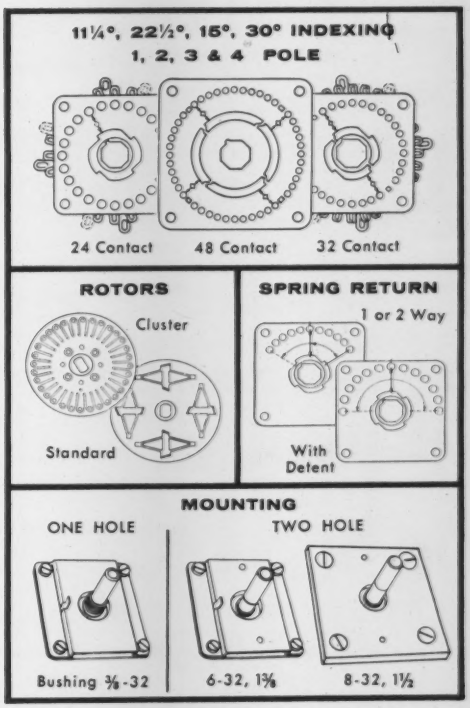
CIRCLE 326 ON READER-SERVICE CARD

NEW Compactness . . . *NEW* Versatility in

ROTARY SWITCH DESIGN



SHALLCROSS *Miniature* ROTARY SELECTOR SWITCHES give the long-lasting dependability of multi-leaf wiper, button-contact design . . . *and* the added advantages of compactness and new versatility. The sketches below detail some of the many unusual features of this new switch series . . .



ELECTRICAL SPECIFICATIONS: Operating Voltage—to 2000 volts; Breakdown Voltage—to 3000 volts; Breaking Current—5 amp @ 125 V. ac.; Carrying Current—15 amp.

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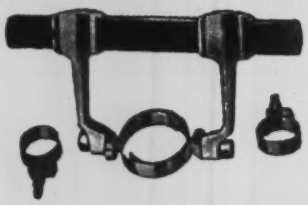

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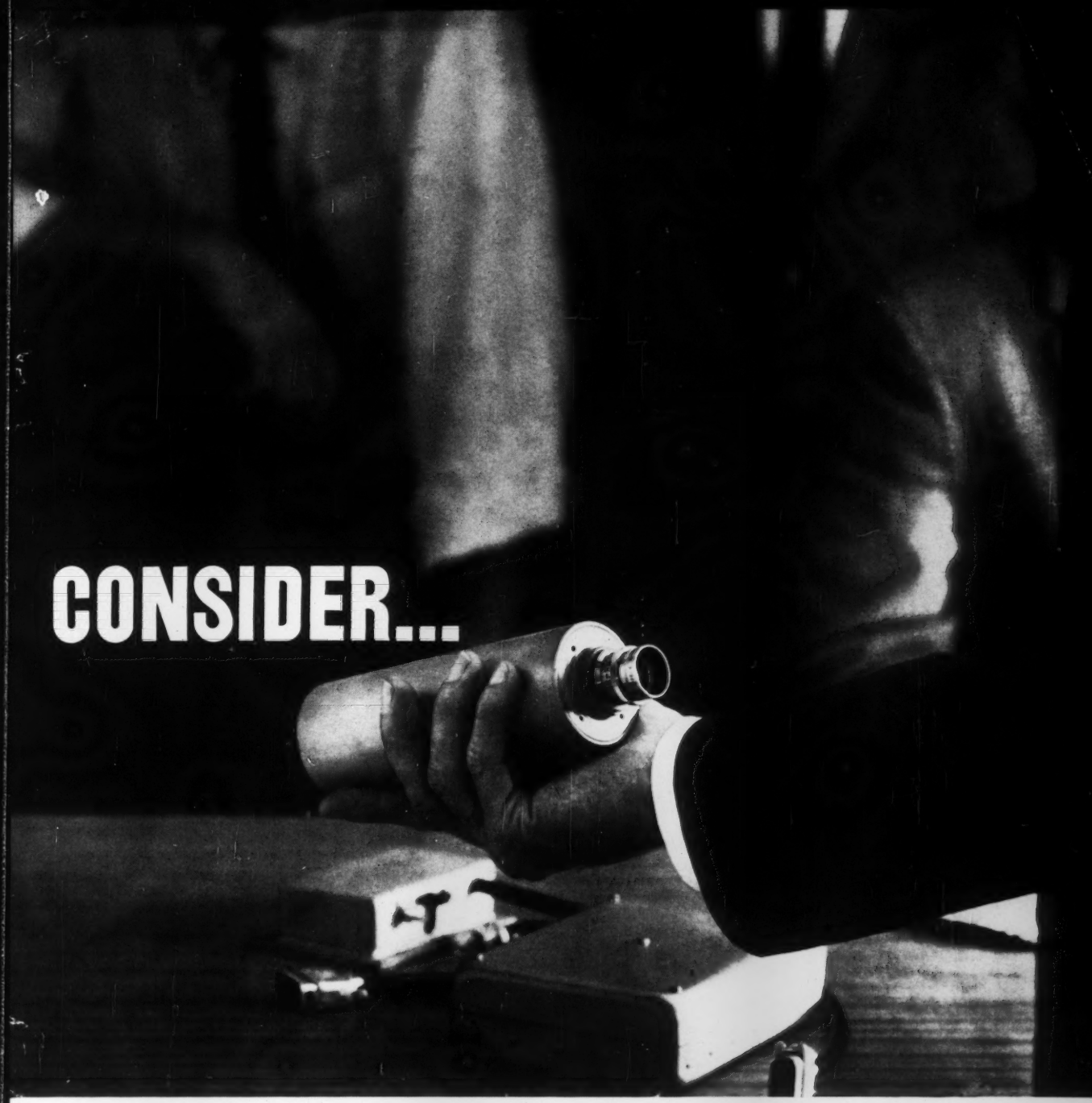

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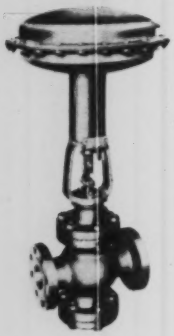

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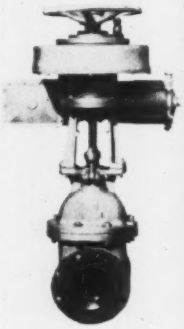

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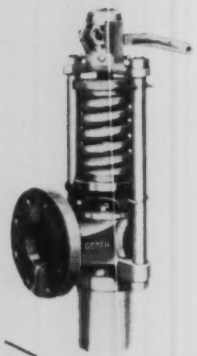

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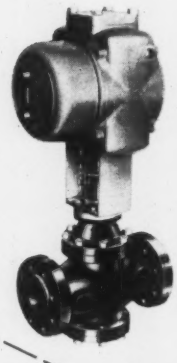

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